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INDIAN FOREST RECORDS

Vol. XVIII] 1933 [Part I

ENTOMOLOGICAL INVESTIGATIONS ON THE SPIKE DISEASE OF SANDAL (4).

CERCOPIDAE (HOMOPT.).

By

Dr. V. LALLEMAND,

Uccle, Belgium.

[Cercopidae are not common on sandal. Ecological observations suggest that they have no bearing on the problem of spike-disease, and they are therefore not tested in transmission experiments. Among the Hemiptera, the family is unique in being better represented at Fraserpet than at localities in North Salem. No. 6, *Peuceptyelus sigillifer* Walker is the dominant species; attempts were made to rear it in 1930 and 1931 without success. Nos. 3 and 4, *Ptyelus affinis* and *P. praefractus*, were tried in 1931 by Mr. Chatterjee in North Salem and it was ascertained that they do not thrive on sandal.

The localities mentioned in this paper are :—

COORG : North Coorg Forest Division, within five miles of Fraserpet, elevation about 2,770 feet, Sample Plots, Nos. 1 to 7.

MADRAS : North Salem Forest Division ; within four miles of Aiyur, elevation about 2,850 feet, Sample Plots, Nos. 15 to 21 ; Denkanikota, elevation about 2,900 feet ; Jawalagiri, elevation about 3,050 feet, Sample Plots, Nos. 8 to 14.

For further details of the collecting stations of the Forest Research Institute Survey of the insect fauna of sandal, *Santalum album* Linn., *see* Ind. For. Rec., Vol. XVII, Part IX. C. F. C. B.].

Note.—Translated and rearranged, with the author's permission, by C. Dover. Additions by C. F. C. Beeson.

APHROPHORINAE.

Ptyelini.

1. **Poophilus costalis** Walk.

Aiyur: VII. 30 (2 exs.); plot 15-II-31 (1 ex.); plot 19-I-31 (2 exs.). Jawalagiri: plot 8, XII. 30 (2 exs.); plot 10, XI. 30 (1 ex.); plot 11, I. 31 (2 exs.).

2. **Ptyelus nebulosus** Fabr.

Aiyur: VI-VII. 30 (2 exs.); plot 15, I. 31 (1 ex.), IV. 31 (1 ex.); plot 18, I. 31 (1 ex.); plot 19, I-III. 31 (5 exs.); plot 21, I. 31 (1 ex.). Jawalagiri: plot 10, II. 31 (1 ex.). Fraserpet: plot 6, IX. 30 (1 ex.); VII. 30 (1 ex.).

3. **Ptyelus affinis** Dist.

Aiyur: II. 30 (1 ex.); plot 20, II. 31 (1 ex.). Jawalagiri: plot 12, III. 31 (1 ex.). Fraserpet: II. 30 (2 exs.); plot 1, X. 30 (1 ex.), I. 31 (1 ex.), V. 31 (1 ex.); plot 3, IX-X. 30 (2 exs.), XII. 30 (1 ex.); plot 5, X. 30 (1 ex.); plot 6, II. 31 (1 ex.); plot 7, VIII. 30 (1 ex.), II. 31 (1 ex.).

This species and P. *hirsutus* Kirby are probably only varieties of *P. nebulosus*, all three having the following characteristics: a small brilliant black patch at the end of the hemelytra; a second patch of the same colour, surrounded by a pale semi-circle, situated posteriorly on the inner margin of the clavus; two small black spots on the head anteriorly. The external genitalia are also similar.

4. **Ptyelus praefractus** Dist.

Fraserpet: VI. 30 (2 exs.); plot 7, VIII. 30 (1 ex.). Jawalagiri: plot 11, III. 31 (1 ex.).

5. **Beesoniella sylvestris** Lall., gen. et sp. nov.

Fraserpet: VIII. 30 (1 ex.), XII. 30 (2 exs.); plot 1, XII. 30 (1 ex.), I. 31 (1 ex.); plot 2, I. 31 (1 ex.), II. 31 (1 ex.); plot 5, I. 31 (1 ex.); plot 6, I. 31 (1 ex.), II. 31 (2 exs.); plot 7, XII. 30 (1 ex.).

Beesoniella gen. nov.

Pronotum very long, almost as long as broad, very convex anteriorly, concave posteriorly, the surface, punctuated in more or less transverse lines, the punctuation more dense posteriorly than anteriorly. Scutellum elongate, ending in a tapering point. The head presents a rounded line from pronotum to clypeus when seen from the side, seen from above it appears as straight band. Eyes (the anterior margins of which continue the general line) not prominent. Ocelli situated a little nearer the eyes than to each other and to the front of the anterior margin of the pronotum near the jugal plates, which are nearly as long as the eyes and slant almost perpendicularly. Clypeus almost smooth, lightly striated on the sides, slightly marked. Antennae situated between the extremities of the eyes and the lateral angles of the clypeus, basal joints short. Labrum a little wider than long; rostrum extending to the end of the median legs. Posterior tibiae with two spines, a small one near the base and a very long one a little above the middle. Hemelytra densely punctuated, slightly transparent; clavus with two nervures further apart from one another at their extremities at the internal margin than at the base; on the corium the radius bifurcates from the middle to the end; the median and cubitus are joined on the anterior third; towards the apex a transverse nervure connects the four longitudinal branches, forming four to five apical cells (according to whether it reaches the external edge or not).

I dedicate this genus to Dr. C. F. C. Beeson, through whom I received the sandal Cercopidae for study.

Beesoniella sylvestris sp. nov.

Ventral surface of body, head and anterior part of pronotum light brownish yellow; posterior part of pronotum, scutellum and hemelytra clear brown. The following markings are black: on the pronotum large widely separated spots situated piincipally on the anterior part, fine spots becoming more dense posteriorly, and an elongate median patch behind the anterior margin; a large spot on the clypeus a little below the ocelli, where the curve is greatest; the ocelli and the small spots on the margins of the jugal plates, the rostrum, the longitudinal lines on the femora and on the anterior and middle tibiae, the extremities of the spines and the posterior tibiae. A brownish black marking, on each side of the rostrum, is found on the mesosternum.

Length: 6 mm.

Habitat: COORG: Fraserpet.

Type: From Fraserpet, plot 6, 4. II. 31.

Aphrophorini.

6. **Peuceptyelus sigillifer** Walk.

Aiyur: II-IX. 30 (several exs.); plot 15, V. 31 (1 ex.); plot 16, XII. 30 (1 ex.), I. 31 (1 ex.); plot 17, VIII. 30 (1 ex.), XII. 30 (2 exs.), VI. 31 (1 ex.); plot 18, IX. 30 (1 ex.); plot 20, IX. 30 (1 ex.), XI-XII. 30 (5 exs.), III. 31 (1 ex.); plot 21, II-III. 31 (3 exs.). Jawalagiri: IV-VII. 30 (several exs.); plot 6, VI-VII. 30; plot 8, X. 30 (1 ex.); plot 9, VIII-IX. 30, I. 31; plot 11, III. 31 (2 exs.); plot 12, IV. 31 (1 ex.). Denkanikota:

V-VI. 30 (3 exs.). Fraserpet: II-III. 30 (several exs.), V. 30 (3 exs.), VI-VII. 30 (several exs.), VIII. 30 (1 ex.), X. 30 (1 ex.); plot 1, VIII-XII. 30 (several exs.), I-III. 31 (18 exs.), VI. 31 (3 exs.); plot 2, VIII. 30 (1 ex.), XI. 30 (1 ex.), I. 31 (3 exs.); plot 3, VIII-IX. 30 (6 exs.), X. 30 (1 ex.), I-V. 31 (8 exs.); plot 4, VIII. 30 (4 exs.), IX. 30 (1 ex.), XII. 30 (4 exs.), I-II. 31 (7 exs.), IV. 31 (2 exs.); plot 5, VIII-IX. 30 (4 exs.), XII. 30 (1 ex.), I. 31 (1 ex.), IV. 31 (1 ex.), V. 31 (1 ex.); plot 6, VIII-IX. 30 (9 exs.), XI-XII. 30 (4 exs.), I. 31 (1 ex.), V. 31 (1 ex.): plot 6, VIII-IX. 30 (9 exs.), X-XII. 30 (4 exs.), I. 31 (1 ex.), V. 31 (4 exs.). This species is most abundant at Fraserpet, particularly in plot 1, and least common at Jawalagiri.

In the collection sent to me there are several examples with a hardened oblique line on each hemelytron, which passes almost to the middle of the external edge and then towards the end of the scutellum, crossing the radius before its bifurcation and passing to the point of separation of median and cubitus. This species is as variable in its dorsal markings as *Philaenus spumarius*, and certain varieties recall those of the latter. All the examples are not attributable to a well-determined variety and there are numerous intermediate forms. The colouration varies from yellow-ochre to brown and brown spots may be present or not. The pronotum may show several markings: (*a*) the anterior half may be yellow-ochre and the posterior half brown-black or black; (*b*) it may be entirely black except for a straight transverse yellow line; (*c*) it may be black except for four yellow marks, of which the median two are more or less lunate in form and the other two are near each lateral margin. The design of the hemelytra is equally varied and, in addition to those described by Walker, there are the following varieties: (*a*) on a ground-colour of brown there is an oblique greyish-white band, the posterior end of which is formed by a hard line; (*b*) on a ground-colour of clear ochre-brown there is a blackish brown longitudinal band, which runs from the base of the corium to the apex and is thickened at the back of the hard line; a second band is found on the clavus, passing along the inner border and extending to the pronotum and scutellum.

Aphrophora trifasciata Distant is undoubtedly a variety of *P. sigillifer*. In this form the median line of the pronotum may be absent and on the hemelytra the black colouration is more or less strongly prolonged.

CERCOPINAE.

Eoscartini.

7. **Eoscarta** sp.

A singleton, probably new, from Fraserpet, plot 1, 22. VIII. 30.

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INDIAN FOREST RECORDS

Vol. XVIII] 1933 [Part II

ENTOMOLOGICAL INVESTIGATIONS ON THE SPIKE DISEASE OF SANDAL (5).

BRENTHIDAE AND LYCIDAE (COL.).

BY

R. KLEINE,

Stettin, Germany.

The Brenthid fauna of sandal is represented only by stray specimens of five species, one of which is of interest in that it belongs to a myrmecophilous genus. The Lycidae, which are chiefly flower feeders in the imaginal state, are represented by seven species, *Lycostomus praeustus* being the most abundant. Further information on the species recorded below will be found in my contributions to the *Catalogue of Indian Insects* series (pt. 11—Brenthidae, 1926; pt. 21, Lycidae, 1931).

[The localities mentioned in this paper are :—

COORG: North Coorg Forest Division, within five miles of Fraserpet, elevation about 2,770 feet, Sample Plots, Nos. 1 to 7.

MADRAS: North Salem Forest Division; within four miles of Aiyur, elevation about 2,850 feet, Sample Plots, Nos. 15 to 21; Denkanikota, elevation about 2,900 feet; Jawalagiri, elevation about 3,050 feet, Sample Plots, Nos. 8 to 14; Noganur, elevation about 2,900 feet.

For further details of the collecting stations of the Forest Research Institute Survey of the insect fauna of sandal (*Santalum album* Linn.) see Ind. For. Rec., Vol. XVII, part IX.

Two species of lycid beetles, *Lycostomus madurensis* and *L. praeustus*, that frequent the flowers of sandal have been included in the list of insects under suspicion as possible vectors of the spike disease, and experiments with the latter species are being conducted by Mr. C. Dover at Bangalore. C. F. C. B.]

NOTE.—Rearranged, from a translation by C. F. C. Beeson, by C. Dover, with the author's permission.

BRENTHIDAE.

1. **Cyphagogus westwoodi** Parry.

Fraserpet: 25-II-30 (1 ex. *N. C. C.*); plot 1, 19-XII-30 (1 ex.).

A very widely distributed species recorded by Beeson from the galleries of *Crossotarsus squamulatus* and in numerous species of trees attacked by Platypodidae. All the species of *Cyphagogus* are predators.

2. **Cerobates sexsulcatus** Motsch.

Fraserpet: 19-V-30 (1 ex.).

Apparently an exceedingly polyphagous borer of wide distribution. *Albizzia lucida, Butea frondosa* and *Dysoxylum binectariferum* are known as host-plants.

3. **Araiorrhinus beesoni** Kleine.

Aiyur: plot 20, 7-XI-30 (1 ex.).

Previously recorded from Katha Division, Burma (under bark of teak).

4. **Symmorphocerus cardoni** Senna.

Jawalagiri: 31-V-30 (1 ex.).

This species appears to be fairly widely distributed in India. The genus is myrmecophilous.

5. **Eupsalis truncata** Boh.

Jawalagiri: plot 9-23-IX. 30 (1 ex.).

Occurs, not infrequently, in Ceylon, the Indian Peninsula and Bengal. *Artocarpus integrifolia* is the only recorded host-plant.

LYCIDAE.

1. **Lycostomus madurensis** Pic.

Fraserpet: VI-VII. 30 (4 exs.).—Jawalagiri: VI-VII. 30 (19 exs.); plot 8, VII. 30 (2 exs.); plot 9, V. 30 (5 exs.); plot 11, V. 31 (2 exs.); plot 14, V. 31 (3 exs.). Aiyur: V-VII. 30 (fairly common); plot 15, V. 31 (3 exs.); plot 16, V. 31 (3 exs.); plot 19, V-VI. 31 (fairly common); plot 20, V. 31 (3 exs.), VI. 31 (4 exs.); plot 21, V. 31 (2 exs.). Noganur: V-VI. 30 (2 exs.).

The foregoing are the only definite localities in India from which this species is known. *L. madurensis* and *L. praeustus* are the two species of Lycidae recorded by Hart and Rangaswamy (*Ind. Forester,* LII, 1926) as feeding on the nectar and pollen of sandal flowers.

2. **Lycostomus praeustus** Fabr.

Fraserpet : VI-VII. 30 (5 exs.).—Jawalagiri : V. 30 (6 exs.), VI-VII (very abundant) ; plot 8, VIII. 30 (13 exs.), VII. 31 (19 exs.) ; plot 9, VIII. 30 (14 exs.), V. 31 (7 exs.), VI. 31 (9 exs.), VII-VIII. 31 (very abundant) ; plot 11, VIII. 30 (1 ex.), V. 31 (3 exs.) ; plot 12, VII. 31 (23 exs.) ; plot 13, VII. 31 (2 exs.) ; plot 14, V. 31 (20 exs.). Aiyur : V-VII. 30 (common) ; plot 16, VIII. 30 (3 exs.), V. 31 (2 exs.) ; plot 19, VIII. 30 (9 exs.), V. 31 (13 exs.), VI. 31 (27 exs.) ; plot 20, V-VI. 31 (5 exs.) ; V-VI. 30 (2 exs.). Noganur : V. 30 (21 exs.). Denkanikota : VI. 30 (7 exs.).

This widely distributed species is the commonest Lycid on sandal in North Salem, occurring between May and August. In the plots it appears to be most common in 9 and 19, in both of which Lantana and *Acacia leucophloea* are the dominants. Experiments are in progress to determine if " spike-fed " individuals of this species can transmit the disease to sandal *via* the flowers.

3. **Lycostomus lateritius** Gorham.

Jawalagiri : plot 8, VII. 30 (1 ex.).

This species is fairly widely distributed in British India.

4. **Lycostomus similus** Hope.

Aiyur : V. 30 (1 ex.). Denkanikota, V. 30 (1 ex.).

A common and widely distributed species found particularly in hilly regions.

5. **Xylobanus montanus** Kleine.

Aiyur : plot 21, XII. 30 (1 ex.).

Previously recorded only from Tavoy and the Karen hills.

6. **Plateros imitator** Kleine.

Fraserpet : VII. 30 (9 exs.), VIII. 30 (1 ex.) ; plot 3, IX. 30 (3 exs.) ; plot 6, VIII-IX. 30 (2 exs.), VII. 31 (1 ex.).—Jawalagiri : VI. 30 (2 exs.) ; plot 8, VII. 30 (2 exs.), X. 30 (1 ex.) ; plot 9, V. 31 (2 exs.), VII. 31 (2 exs.) ; plot 10, VII-VIII. 30 (2 exs.) ; plot 11, V-VIII. 31 (5 exs.) ; plot 12, VII-VIII. 31 (3 exs.). Aiyur : VI-VII. 30 (5 exs.) ; VI. 31 (3 exs.), VIII. 31 (1 ex.).

Previously known from Malabar, the United Provinces (Haldwani Division) and Bengal.

7. **Calochromus andrewesi** Kleine.

Jawalagiri: plot 9, V. 31 (2 exs.). Aiyur: V. 30 (common), VI. 30 (3 exs.); plot 17, VI. 31 (5 exs.); plot 19, IV. 31 (21 exs.), V. 31 (39 exs.), VI. 31 (14 exs.); plot 20, V. 31 (17 exs.), VIII. 31 (1 ex.); plot 21, VII-VIII. 31 (2 exs.).

Only known from South India (the Nilgiris and the above localities). The species appears to be fairly common between April and August but occurs spasmodically. The variation is so considerable that one might conclude that several species were represented. The elytra may be uniformly coloured, but the posterior margin may also be darkened to a more or less great extent. The scutellum of such individuals is then often blackish brown; the antennae are blackish brown, only the first segment being yellow; abdomen blackish brown; thorax yellow; femora usually yellow, occasionally with black anterior margins; tibiae and tarsi dark coloured. This variation is not common, and individuals with uniformly coloured elytra should be considered the typical form. In these specimens the scutellum is always yellowish as the whole upper surface of the body. The antennae may be coloured yellow up to the fourth segment. The colour of the legs is variable. Usually the femora are yellow, tibiae and tarsi dark coloured. The anterior margins of the femora are also not infrequently darkened. The underside of the body may be quite yellow, but the abdomen is usually dark. All possible combinations occur, and quite uniformly yellow individuals are even found. The size of this small species varies by about 1-2 mm. The most certain character is the strong pubescence of the elytra and the form of the penis in the male.

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INDIAN FOREST RECORDS.

Vol. XVIII] 1933 [Part III

ENTOMOLOGICAL INVESTIGATIONS ON THE SPIKE DISEASE OF SANDAL (6).

ANTHRIBIDAE (COL.).

BY

DR. KARL JORDAN,

Tring, England.

It was not to be expected that such a specialised entomological survey as that of a single species of forest tree would result in the amassing of a large number of species of Anthribidae, the family being, among beetles, a comparatively small one. The 112 specimens submitted for determination belong to 17 species, 4 of which are new, a fifth being represented by a new subspecies. The distribution of the species is as follows: 5 known from South India only, 3 from Ceylon and South India, 1 from Ceylon and South and Northern India, 2 from South and Northern India, 1 from South and Northern India and Tonkin, 5 extending in to the Malaysian countries.

For the seasonal distribution of the species compare the table at the end of this article.

[The localities mentioned in this paper are :—

COORG : North Coorg Forest Division, within five miles of Fraserpet, elevation about 2,770 feet, Sample Plots, Nos. 1 to 7.

MADRAS : North Salem Forest Division; within four miles of Aiyur, elevation about 2,850 feet, Sample Plots, Nos. 15 to 21 ; Denkanikota, elevation about 2,900 feet; Jawalagiri, elevation about 3,050 feet, Sample Plots, Nos. 8 to 14.

For further details of the collecting stations of the Forest Research Institute Survey of the insect fauna of sandal, *Santalum album* Linn., see Ind. For. Rec., Vol. XVII, Part IX.—C. F. C. B.]

1. Tropideres securus Boh.

Tropideres securus Boheman in Schoenh., Gen. Curc. V. p. 207 No. 3 (1839) (Calcutta).

Litocerus rufescens Roelofs, C. R. Soc. Ent. Belg. XXII. p. LV No. 20 (1879) (Japan).

Litocerus anna Jordan, Nov. Zool. X, p. 424 No. 26 (1903) (Kina Balu, Borneo).

Fraserpet: 9-III-30, one specimen—Also known to me from Coimbatore, Madras, Darjiling and Assam; its area of distribution extends to Japan, Borneo and Java, possibly farther east. The original description by Boheman is not very precise, but the examination of the type of *T. securus* leaves no doubt that the above synonymy is correct. Evidently fairly common in many districts.

2. Gibber callistus Jord.

Gibber callistus Jordan, Nov. Zool. XXXI. p. 238 No. 18 (1924) (Assam: Lakhimpur).

Fraserpet: 18-III-30 and 14-I-31, a pair—known from Madras and Assam. Upper side grey-green, at base of pygidium a well-defined black spot.

3. Zygaenodes horni Jord.

Zygaenodes horni Jordan, D. Ent. Zeitschr. p. 76 No. 2 (1902) (Ceylon).

Fraserpet: 28-III. and 2-IV-30; 9-VIII-30 and I. 31 on plot 2; 21. and 22-IX-30 on plot 3; 29-XII-30 on plot 5; 18-I-31 and 15-II-31 on plot 3.—Aiyur: 1-V-30; 25-XI-30 on plot 17. Jawalagiri: 12-VI-30 on *Zizyphus*; 18-II-30 on plot 10. Denkanikota: 18-VI-30. An interesting series of a species known only from a single female collected in Ceylon by Dr. Walther Horn. Most of the specimens have a greenish grey tint on the upperside and no sharply defined markings, which may partly be due to the pubescence having somewhat sufferéd in the killing bottle. The length varies from 2·2 to 3·3 mm. (head excluded). The species belongs to that section of the genus in which the eye is sinuate laterally above the antennal groove. The larvae of some species of *Zygaenodes* are known to live in seeds.

4. Zygaenodes antiallus Jord.

Zygaenodes antiallus Jordan, Nov. Zool. XVIII. p. 602 No. 6 (1912) (Assam: Khasia Hills).

Fraserpet: 10-III. and 19-VI-30; 6-IX-30 on plot 2; 21-IX-30 on plot 3; 11-II-31 on plot 6.—Aiyur: 11-XI-30 on plot 17; 4-I-31 on plot 17. Jawalagiri: 26-IX-30 on plot 12; 5-X. and 28-IX-30 on plot 14.—Only a few specimens were hitherto known from Assam and Tonkin. The eye is pointed above the antennal groove, not sinuate, the sinus being feebly indicated on the side adjoining the upper surface of the proboscis. Occiput with a double hump between the eyes. The present specimens vary in length from 3·0 to 4·3 mm.

5. **Uncifer basalis** Jord.

Uncifer basalis Jordan, Ann. Mag. N. H. (9). XVI. p. 259 No. 3 (1925) (Sumatra).

Fraserpet : 20-VI-30, one specimen—Described from one female obtained in East Sumatra by Mr. J. B. Corporaal ; not yet known from other districts.

6. **Uncifer pissodes** spec. nov.

♂. Similar to *U. exillis* Jord. Nov. Zool. XXXII. p. 252 No. 23 (1925) (Perak), antenna shorter, eye not elevate behind, evenly convex. Pitchy black, antenna and legs slightly rufescent. Frons as broad as segment II of antenna is long. Eye broader in an antero-posterior direction than in *U. exillis*. Antenna little longer than the rostrum is broad, segment II as broad as the club, III shorter than II, III to VII decreasing in length, VIII broader than VII, about as broad as long, IX broader than long, broader than VIII, but narrower than X, this broader than long, XI ovate, truncate at base, acuminate at apex, IX to XI rather closely appressed to each other. Dorsal carina of pronotum basal in middle, slightly antebasal at sides. Elytra coarsely punctate-striate. Pygidium longer than broad, narrowing apicad, inclining forward, ventral segment V being very short in middle, basal margin of pygidium slanting from middle to sides, apex evenly rounded.

Pubescence grey, sparse on upperside, somewhat denser on proboscis, on sides of pronotum and on and behind scutellum.

COORG : Fraserpet, 15-II-30, one male.

7. **Atinella senex grisea** subsp. nov.

♂ ♀. A little narrower than *A. senex senex* Jord. Nov. Zool. XXXIII. p. 252 No. 22 (1925) (Ceylon) ; dorsal carina of pronotum medianly less incurved and laterally a little more convex ; tarsi blackish brown except larger proximal portion of segment I ; middle of femora brown. Pubescence grey, not very dense on upperside, densest in front of scutellum ; pronotum sometimes with a grey median line ; lateral median area of elytra more sparsely grey, sometimes this area rather better defined, narrowing dorsally and ending at some distance from the suture with an oblong brown spot. Pygidium in ♂ longer than broad, in ♀ broader than long (♂ not known of *A. senex senex*).

Length (head excl.) 2·0 to 3·1 mm.

COORG : Fraserpet, 20 and 25-III-30, 3, 5 and 6. III-30, 5 and 6. IV-30—on spiked sandal, 5 and 14. VI-30 ; 23-VI-30 on plot 5, 30-IX-30 on plot 5, 22-XI-30 on plot 2.—NORTH SALEM ; Denkanikota : 2-VI-30 on spiked sandal. Noganur : 1-IV-30, 17-V-30. Jawalagiri : 15-V-30 on spiked sandal.

8. **Physopterus analis** Jord.

Physopterus analis Jordan, Nov. Zool. XIII. p. 408 No. 2 (1906) (Anamalai Hills, May).

Fraserpet : 23-XII-30 on plot 6 ; 9-I-31 on plot 1 ; 4-II-31 on plot 6.—Denkanikota : I-VI-30.—The ♂ bears on the underside of the hind femur a subapical pointed tooth, which is somewhat curved. Only a few specimens are known, all from South India.

9. **Exillis asper** Jord.

Exillis asper Jordan, Ann. Mag. N. H. (9). XVI. p. 264 No. 11 (1925) (Sumatra).

Fraserpet : 16-VIII-30 on plot 2 ; 9-XI-30 on plot 3 ; 13-XII-30 on plot 2 : 4-I-30 on plot 3.—Jawalagiri : 3-VIII-30 on plot 14 ; 13-X-30 on plot 8.—Previously known from North India and Sumatra. In colour closely agreeing with *E. horni* Jord., D. Ent. Zeitschr. p. 77 No. 5 (1902), from Ceylon but the lateral carina of the pronotum longer.

10. **Basitropis hamata** Jord.

Basitropis hamata Jordan, Nov. Zool. X. p. 132 (1903).

Jawalagiri : 6-V-30, one specimen—Widely distributed in India and Indo-China.

11. **Phloeobius alternans** Wiedem.

Anthribus alternans Wiedemann, Zool. Mag. I. 3. p. 172 No. 22 (1819) (Bengal).

Anthribus apicalis Walker, Ann. Mag. N. H. (3). III. p. 262 (1859) (Ceylon).

Fraserpet : 17-VI-30, one ♀.—A common species, the range of which extends to Borneo, Celebes and Java.

12. **Phloeobius albescens** Jord.

Phloeobius albescens Jordan, Ent. Zeit. Stettin LVI. p. 198 No. 91 (1895) (locality not mentioned in original description ; the 2 specimens were obtained by Fruhstorfer on Mt. Sukabumi, W. Java).

Fraserpet : 3. and 14-VI-30 ; 17-I-31 on plot 2—In our collection from Calcutta, Indo-China, Hainan, Sumatra and Java.

13. **Phloeobius brevitarsis** spec. nov.

♂ ♀. Near *Phloeobius laetus* Jordan, Opusc. Inst. Scient. Indo-chine, Faune Entom. I. p. 103 No. 74 (1923) (Cochinchina), and *Phl. vicinus* Jord., l.c. No. 75 (Tonkin), but angle of pronotum more acute and tarsal segment I shorter. Upperside clay-colour variegated with grey-white and blackish brown. Head and rostrum shaded with grey-white in middle and at sides, this colour concentrated on occiput into three diffuse spots. Apical margin of rostrum rather sharp, elevate in middle, not slanting as in *Phl. laetus* and *Phl. vicinus*. Edge of antennal groove sharp near eye, the space between it and the eye narrower than in the species mentioned. The eye less transverse and its sinus smaller and less obtuse. Antenna of ♂ a little longer and that of ♀ shorter than the elytra are broad, rufous, with black club, segment III as long as IV, anterior apical angle of IX and X acute, more produced than posterior angle, IX about a third longer than broad in ♂, less than a third in ♀, X slightly broader than long, a little broader than IX and X, XI ovate, about as long and broad as IX.

On pronotum a grey-white dot before middle on each side of disc, a blackish brown spot laterally at apex and another at carina nearer to angle than to middle ; sides rounded-angustate from carina forward, the apex very little broader than the neck, posteriorly the sides more strongly incurved than in the allied species, therefore the basal angle smaller and more projecting ; surface more finely granulate than in *Phl. laetus.* Elytra as in the allied species without tufts, suture and alternate interspaces grey-white spotted with black-brown, apical area more or less distinctly grey-white, not impressed, at apex of suture a black-brown spot. Pygidium much larger and much less rounded in ♂ than in ♀, in ♂ about one-sixth broader at base than long, in ♀ one-fourth ; middle of apical margin in ♀ more or less impressed, sometimes emarginate. Underside grey-white shaded in places with clay-colour. Legs rufous, tarsal segments II to IV more or less black ; pubescence of tibiae long, particularly on underside, segment I of tarsi short in foretarsus of ♂ shorter than II, III, these dilated, especially in fore and midtarsus, but rather less so than in *Phl. laetus* and *Phl. vicinus.*—Length (head excl.) 4 to 9 mm.

COORG : Fraserpet : 28-II-30 on unspiked sandal ; 26-IV-30 ; 6. 12. and 17-V-30 ; 15. and 16-VI-30 ; VII-30 ; VIII, 14-IX—30, X, XII and 11-I-31 on plot 3 ; 4-VIII, IX and X. 30 on plot 4 ; 26-XI-30 on plot 6 ; VIII, IX, X, XI and XII on plot 7,—NORTH SALEM : Aiyur, 4-I-31 on plot 15 · X. 30 on plots 18 and 21 ; 4-XII-30 on plot 19.

14. **Phloeobius crassicollis** spec. nov.

♂ ♀. Not unlike the preceding new species, but the pronotum much broader at apex. Colouring evidently nearly the same (the three specimens are not well preserved), but the elytra less spotted with black and the tarsi, tip of tibiae and the greater part of the femora black-brown. Eye more convex, and more rounded, being almost circular apart from the sinus, which is small. Pronotum less narrowing from lateral carina to apex, remaining much wider than the neck, though rounded off, the lateral carina at least one-fourth longer than the distance from the end of this carina to the angle of the apex; basal angle of carina a little less acute than in *Phl. brevitarsis*. Pygidium evenly rounded in both sexes, in ♂ one-third broader than long, in ♀ two-fifths. Prosternum shorter than in *Phl. brevitarsis*, anterior margin of coxal groove somewhat raised and continued laterad as an obtuse ridge. Pubescence of legs apparently shorter than in *Phl. brevitarsis*, first segment of tarsi distinctly longer than in that species. Length ♂ 5 mm., ♀ 8 mm.

COORG: Fraserpet, 1-VI-30 (♂ type) and 11-I-31, ♀.—NORTH SALEM: Aiyur, 11-IX-30 on plot 21.

15. **Phloeobius santalinus** spec. nov.

♂ ♀. Resembles *Phl. crassicollis* in the pronotum being wide at apex, but the eye is very much narrower, almost as narrow as in *Phl. gigas* F. 1775.

Cylindrical, above buff variegated with grey-white, beneath grey-white. Head and proboscis greyish in middle, irregularly rugulose, with indication of a median depression on rostrum. Frons at least one-third broader than the area in front of eye, in ♀ usually broader than in ♂. Antenna rufous, club black, in ♂ variable in length, the end-segment being either long and pointed (type) or only as long as IX, with intergradations. Pronotum clay-colour, on each side of disc as usual an antemedian white dot, behind which there is a smaller one, about 5 diffuse confluent blackish patches on each side, the basal patch placed nearer to side than to middle better defined and oblong; side of pronotum from lateral carina forward moderately slanting, the pronotum remaining much broader than the neck of the head, this portion of the side shorter than the lateral carina, as in *Phl. crassicollis*; basal angle 90°, with the tip rounded off. Elytra pubescent luteous, without tufts, suture and alternate interspaces diffusely spotted with grey-white, behind middle and on apical area some, more conspicuous, white dots, before apex of suture a black spot which is about twice as long as broad. Pygidium evenly rounded in both sexes, at least twice as broad as long. Legs rufous, the greater part of the femora, and tarsal segments II and

III and apex of IV black or black-brown, II and III very slightly dilated, together about one-third shorter than I.—Length (head excl.) 4·2 to 7·6 mm.

COORG : Fraserpet ; IX-30 and 13-II-31 on plot I ; 18-I-31 on plot 3.—NORTH SALEM : Aiyur ; 1-III-30 ; 2., 9., 24., and 25 IV-30 ; 9-V-30 ; 10., 24. and 25-VI-30 ; 3-VIII-30 on plot 16 ; 13-V-31 on plot 18 ; 5-I-31 and 25-V-31 on plot 16 ; 10-VI-31 on plot 18. Type from Aiyur.

16. **Phloeobius ceylonicus** Jord.

Phloeobius ceylonicus Jordan, D. Ent. Zeitschr. p. 78 No. 6 (1902((Ceylon).

Fraserpet : 28-II-30 ; 2-V-30 and 17-VI-30, three ♀♀.—We have a few specimens from Kanara, Madura and Juranda.

17. **Araecerus suturalis** Boh.

Araecerus suturalis Boheman, in Schoenherr, Gen. Curc. V. p. 273 No. 3 (1839) (Calcutta).

Araeosarus intangens Walker, Ann. Mag. N. H. (3). III. p. 262 (1859) (Ceylon).

Fraserpet : 1. and 17-VII-30 ; 1-X-30 on plot 6 ; 1., 2. and 31-XII-30, one each on plots 4, 5, 6.—Aiyur : 23-IV-30 ; 2-XI-30 on plot 15 ; 14-XI-30 on plot 20 ; 16-XI-30 on plot 15 ; 6-XII-30 on plot 17 ; 8-XII-30 on plot 16 ; 9-XII-30 on plot 17 ; 10-XII-30 on plot 18 ; 13-XII-30 on plot 21 ; 14-XII-30 on plot 15 ; 12-I-31 on plot 16. Jawalagiri : 30-VI-30 ; 6-X-30 on plot 8 ; 27-X-30 on plot 14 ; 28-X-30 on plot 8 ; 9-XI-30 on plot 13 ; 21-XII-30 on plot 13.

In our collection from Ceylon, Travancore, Dehra Dun and Pusa. The majority of specimens have the alternate interspaces of the elytra strongly dotted ; Walker's *intangens* was based on an example of this colour-type according to the British Museum collection. Walker's diagnosis is a joke : " Nigro-cinereus, elytris cinereo substrigatis. Long. 1½-1¾ lin." In the rarer colour-form, described by Boheman as *suturalis*, the elytra bear a broad pale stripe from the shoulder to the apex, the suture appearing darker and the dots being more or less suppressed. Intermediate specimens also occur. In the present series there are 9 examples of the *suturalis*-form, all among the specimens from North Salem. Such dichromatism occurs also in some other species of *Araecerus*, for instance *A. simulatus* Gylh. 1833. The ♂ of *A. suturalis* (both forms, of course) has a long pygidium. The larvae of *Araecerus* feed in seeds.

The locality richest in Anthribidae is Fraserpet, where 16 out of the 17 species obtained during the Sandal Survey were found, the four localities in North Salem yielding only 9 species. Although the collection is small, owing to the restricted object of the survey, the careful labelling affords some evidence as to the seasonal distribution of Anthribidae in South India, as shown in the following table.

Month	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
1. Tropideres securus . .	..	..	×	..	..	..	..	..	..	..	..	..
2. Gibber callistus . .	×	..	×	..	..	..	..	..	..	..	..	..
3. Zygaenodes horni . .	×	×	×	×	×	×	..	×	×	..	×	×
4. ,, antiallus .	×	×	×	..	..	×	..	..	×	×	×	..
5. Uncifer basalis . .	..	..	..	..	..	×	..	..	..	.	..	..
6. ,, pissodes . .	..	×	..	..	..	..	..	..	..	..	..	..
7. Atinella senex grisea .	..	..	×	×	×	×	..	..	×	..	×	..
8. Physopterus analis . .	×	×	..	..	..	×	..	..	..	..	..	×
9 Exilis asper . . .	×	..	..	..	..	..	..	×	..	×	×	×
10 Basitropis hamata . .	..	..	.	..	×	..	..	..	..	..	.	..
11. Phloeobius alternans .	..	..	..	..	..	×	..	..	..	.	..	.
12. ,, albescens .	×	..	..	..	..	×	..	..	..	..	..	.
13. ,, brevitarsis .	×	×	×	×	×	×	×	×	×	×	×	×
14. ,, crassicollis .	×	..	..	..	..	×	..	..	×	..	.	.
15. ,, santalinus .	×	×	×	×	×	×	..	×	×	..	.	.
16 ,, ceylonicus .	..	×	..	..	×	×	..	..	..	.	.	.
17. Araecerus suturalis . .	×	..	..	×	..	×	×	..	..	×	×	×
	10	7	7	5	6	12	2	4	6	4	6	5

The species were most numerous in January and June. Several of them may be expected to occur in all months ; whether others are restricted to certain seasons cannot as yet be ascertained, the data available not being extensive enough for the solution of such a problem.

MGIPC—M—III-2-116—16-6-33—500.

INDIAN FOREST RECORDS

Vol. XVIII] 1933 [Part IV

ENTOMOLOGICAL INVESTIGATIONS ON THE SPIKE DISEASE OF SANDAL (7).

THE GENUS EXOCENTRUS, CERAMBYCIDÆ (COL.).

BY

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This paper gives the results of a study of several collections of beetles belonging to the genus *Exocentrus* Mulsant, Cerambycidae, sub-family Lamiinae, received from the Forest Research Institute, Dehra Dun, United Provinces, India, and collected in connection with the Institute's Sandal Insect Survey.

[The localities mentioned in this paper are :—

COORG : North Coorg Forest Division, within five miles of Fraserpet, elevation about 2,770 feet.

MADRAS : North Salem Forest Division, within four miles of Aiyur, elevation about 2,850 feet ; Jawalagiri, elevation about 3,050 feet.

For further details of the collecting stations of the Forest Research Institute Survey of the insect fauna of sandal, *Santalum album*, Linn., see Ind. For. Rec., Vol. XVII, Part IX. C. F. C. B.]

1. **Exocentrus flemingiae** Fisher.

Exocentrus flemingiae Fisher, Indian Forest Records, Ent. Ser., 1932, Vol. XVI, pt. x, pp. 3, 4.

One specimen of this species was collected on sandal at Aiyur, May, 27, 1931.

2. **Exocentrus pubescens** Fisher.

Exocentrus pubescens Fisher, Indian Forest Records, Ent. Ser., 1932, Vol. XVI, pt. x, pp. 9, 10.

Specimens of this species were collected at Jawalagiri, May 11-21, June 16, and July 11, 1930, and at Aiyur, September 23, 1930.

3. **Exocentrus vittatus** Fisher.

Exocentrus vittatus Fisher, Indian Forest Records, Ent. Ser., 1932, Vol. XVI, pt. x, pp. 12, 13.

The type of this species was collected at Jawalagiri, May 30, 1930, and the two paratypes were collected at Fraserpet, September 21 and October 6, 1930.

4. **Exocentrus trifasciatus** Fisher.

Exocentrus trifasciatus Fisher, Indian Forest Records, Ent. Ser., 1932, Vol. XVI, pt. x, pp. 13, 15.

Specimens of this species were collected at Fraserpet; March 25, May 12-15, September 14, October 11, and November 14, 1930.

5. **Exocentrus santali,** new species.

Male.—Above and beneath uniformly brownish-yellow, and each elytron ornamented with three distinct, transverse, zigzag, whitish pubescent fasciae.

Head strongly transverse and nearly flat in front, subequal in width to pronotum at apex, flat between the antennal tubercles, which are feebly elevated and widely separated ; surface with a narrow, longitudinal groove extending from epistoma to occiput, rather coarsely but not very densely granulose, rather densely clothed with long, recumbent, yellowish pubescence, with a few long, erect, brownish hairs intermixed ; mandibles brownish-yellow, blackish toward apices ; palpi dark brown, with the tips paler ; eyes large, deeply emarginate, and separated from each other on the top by nearly twice the width of the upper lobe. Antenna slightly longer than the body, uniformly brownish-yellow, sparsely clothed with short, recumbent, whitish and yellowish pubescence, with numerous long, erect hairs intermixed, rather densely ciliate beneath with long, erect, black hairs, and the joints feebly, narrowly annulated at bases with white pubescence ; first joint long, robust, cylindrical, slightly expanded at middle, and extending to basal third of pronotum ; third joint slightly shorter than first joint and subequal in length to the fourth.

Pronotum one and one-half times as wide as long, slightly narrower at base than at apex, and widest near middle ; sides arcuately expanded from apical angles to a small, acute tooth on each side just behind the middle (tooth short, slender, and pointing obliquely backward), then strongly, obliquely narrowed to the base ; surface feebly convex, feebly, broadly, transversely depressed along base, coarsely but not very densely granulose, sparsely clothed with long, recumbent, whitish pubescence, which is slightly denser at middle and on each side, and with a few long, erect, black hairs intermixed. Scutellum broadly rounded at apex, and rather densely clothed with long, recumbent, whitish pubescence.

Elytra nearly four times as long as pronotum, and at base wider than pronotum at middle ; sides parallel from base to apical third, then arcuately narrowed to the tips, which are conjointly, broadly rounded ; disk moderately convex ; surface rather densely, coarsely, irregularly punctate from bases to apices, sparsely clothed with short, recumbent, brownish pubescence, with numerous long, erect, stiff, black hairs intermixed, and each elytron ornamented with white pubescent markings as follows : a broad, transversely arcuate fascia extending from humerus to sutural margin at basal third, then narrowly along the margin to scutellum, a narrow, transversely zigzag fascia at middle, a narrow, transverse, irregular fascia near apex, the fascia narrowly connected along sutural and lateral margins to the median fascia, and enclosing a large, irregular, dark spot.

Beneath feebly, finely, densely punctate, rather densely clothed with long, recumbent, whitish pubescence, with numerous long, erect hairs on the legs ; last abdominal segment broadly subtruncate at apex.

Female.—Differs from the male in having the last abdominal segment strongly convex, broadly, arcuately emarginate at apex, and broadly depressed behind the apical margin.

Length, 5·2 mm.; width 1·8 mm.

Type locality.—MADRAS : North Salem, Jawalagiri.

Other locality.- MADRAS : Palghat, Sappal (1,700 feet elevation).

Type.—British Museum. *Allotype.*—United States National Museum, Washington.

Described from a male and female (male type). The male was collected at the type locality October 7, 1930, in connection with the Forest Research Institute Sandal Insect Survey, and the female was reared from dry sticks collected at Sappal, October 5, 1930, by J. C. M. Gardner. The allotype is more reddish-brown than the type, and the white pubescent markings on the elytra are slightly rubbed.

This species resembles *dalbergiae* Fisher, but that species differs from *santali* in having the head and pronotum more densely granulose, the erect hairs on dorsal surface of body much longer and more conspicuous, the tooth on each side of the pronotum pointing almost directly backward, the eyes more narrowly separated from each other on the top, and the white pubescence forming more or less distinct designs on the pronotum.

6. **Exocentrus beesoni,** new species.

Male.—Above and beneath uniformly dark reddish-brown, and the elytra irregularly variegated with small, whitish pubescent spots.

Head strongly transverse and nearly flat in front, subequal in width to pronotum at apex, feebly, broadly concave between the antennal tubercles, which are slightly elevated and widely separated; surface with a narrow, longitudinal groove extending from epistoma to occiput, rather coarsely but not very densely granulose, rather densely clothed with long, recumbent, whitish and yellowish pubescence, with a few long, erect, brownish hairs intermixed; mandibles reddish-brown, with the tips black; palpi brownish-yellow, with the tips slightly paler; eyes large, deeply emarginate, and separated from each other on the top by nearly twice the width of the upper lobe. Antenna considerably longer than the body (broken), uniformly dark reddish-brown, sparsely clothed with moderately long, recumbent, whitish pubescence, with a few long, erect hairs intermixed, rather densely ciliate beneath with long, erect, dark brown hairs, and the joints feebly, narrowly annulated at bases with white pubescence; first joint long, robust, cylindrical, slightly expanded at middle, and extending to basal third of pronotum; third joint slightly shorter than first joint, and subequal in length to the fourth.

Pronotum one and one-half times as wide as long, slightly narrower at base than at apex, and widest at middle; sides arcuately expanded from apical angles to a small, acute tooth on each side at middle (tooth moderately long, rather slender, and pointing almost directly backward) then strongly, obliquely narrowed to the base; surface feebly convex, feebly, broadly, transversely depressed along the base and anterior margin, rather coarsely but not very densely granulose, rather densely clothed with long, recumbent, whitish and brownish pubescence, the white pubescence more distinct on median part and toward the sides, and with a few long, erect, dark brown hairs intermixed. Scutellum broadly rounded at apex, and rather densely clothed with long, recumbent, whitish pubescence.

Elytra three and one-half times as long as pronotum, and at base distinctly wider than pronotum at middle; sides parallel from base to apical third, then arcuately narrowed to the tips, which are conjointly, broadly rounded; disk moderately convex, and slightly uneven; surface coarsely, irregularly punctate, more densely basally, sparsely clothed with rather short, recumbent, brownish and yellowish pubescence, with a few long, erect, stiff, black and brownish hairs intermixed, and irregularly ornamented with numerous small, white pubescent spots.

Beneath feebly, finely, densely punctate, rather densely clothed with long, recumbent, whitish pubescence, with numerous long, erect hairs on the legs; last abdominal segment broadly rounded or subtruncate at apex.

Female.—Differs from the male in having the last abdominal segment strongly convex, and broadly, arcuately emarginate at apex.

Length, 5·2—5·6 mm. width, 2—2·2 mm.

Type locality.—MADRAS: North Salem, Aiyur.

Type.—British Museum. *Allotype.*—United States National Museum, Washington.

Described from a male and female (male type), which were collected at the type locality, October 17 and November 6, 1930, in connection with the Forest Research Institute Sandal Insect Survey. In the allotype the white pubescent markings on the elytra are more distinct than in the type.

This species is allied to *alboguttatus* Fisher, but that species differs from *beesoni* in having the white pubescent markings on the elytra more distinct, narrower, arranged in longitudinal rows, and each elytron ornamented with an obliquely transverse, whitish pubescent fascia behind the middle.

MGIPC—M—III-2-117—23-6-33—500.

ABSTRACT.

Entomological Investigations on the Spike Disease of Sandal (8) Carabidae (Col.).

Thirty-six species of Carabidae were collected on the foliage of sandal, *Santalum album*, in Coorg and North Salem, Madras, South India, during the course of the survey of the insect fauna of that tree carried out by the Forest Research Institute.

The following 15 new species are described :—*Oxylobus exiguus*, (North Salem) ; *Tachys salemus* (N. Salem) ; *Brachinus sordidus* (N. Salem and Dehra Dun) ; *Holcoderus fissus* (N. Salem and Ceylon), *H. carinatus* (Coorg), *H. superbus* (Coorg, Nilambur and Nilgiris) ; *Dromius capnodes* (Coorg, N. Salem and Mysore) ; *Risophilus beesoni* (Coorg), *R. gardneri* (Coorg), *R. ochroides* (Coorg and Dehra Dun) ; *Pentagonica venusta* (Coorg, Mysore, Mangalore, Belgaum, etc.), *Lebia ocellata* (N. Salem), *L. lunigera* (N. Salem, Nilgiris, Bengal and Ceylon), *L. ephippiata* (N. Salem), *L. campania* (N. Salem, Nilgiris, Palnis, Bombay, Central Provinces, Bengal).

INDIAN FOREST RECORDS

Vol. XVIII] 1933 [Part V

ENTOMOLOGICAL INVESTIGATIONS ON THE SPIKE DISEASE OF SANDAL (8).

CARABIDAE (Col.)

BY

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In the course of the survey of the insect fauna of sandal, *Santalum album* Linn., by the Forest Research Institute, some thirty-six species of Carabidae have been collected upon the various sample plots in the sandal area, but it is doubtful whether any of them has a direct connexion with this species of tree, and plots in the same region, but in the vicinity of other trees, would probably have produced a similar crop. Nevertheless at least *Dromius*, *Lebia*, and *Risophilus* are known tree frequenters, and a considerable proportion of the specimens found belong to the various species of these three genera. The remainder, so far as my knowledge goes, appear to be ground beetles only, but all are predatory and no doubt useful in checking the spread of various pests.

[The localities mentioned in this paper are :—

COORG : North Coorg Forest Division, within five miles of Fraserpet, elevation about 2,770 feet, Sample Plots, Nos. 1 to 7.

MADRAS : North Salem Forest Division ; within four miles of Aiyur, elevation about 2,850 feet, Sample Plots, Nos. 15 to 21 ; Denkanikota, elevation about 2,900 feet ; Devarbetta, elevation about 3,240 feet ; Jawalagiri, elevation about 3,050 feet, Sample Plots, Nos. 8 to 14 ; Noganur, elevation about 2,900 feet ; Uduparani, elevation about 3,090 feet.

For further details of the collecting stations of the Forest Research Institute Survey of the sandal insect association, *see* Ind. For. Recs., Vol. XVII, part IX, C. F. C. B.]

The following is a list of the species, of which no less than seventeen are new : the examples of two of these new species are in a poor state of preservation, but the remaining fifteen have been described and the descriptions will be found at the end of the list. Two keys have also been added to aid in the discrimination of the various species of *Holcoderus*, and *Risophilus*, and a plate will be found among the illustrations to aid in the determination of the various species of *Lebia*. As my Catalogue of Indian Carabidae has recently appeared, it seems unnecessary in the enumeration to add synonyms and additional references and consequently only the original reference is given in each instance, with a note after each species indicating its distribution. The types of all the new species have been placed in the British Museum.

Two single specimens, one of *Callistomimus coarctatus* Laf., the other of *Mastax vegeta* Andr., were also included in the collection, both labelled "Fraserpet". These species, as far as I know, are both confined to the Himalayas, and, as I am informed that in February 1930 collections from Dehra were being mounted at the same time as the sandal material, I feel little doubt that the specimens in question were actually found in the neighbourhood of Dehra Dun and were labelled "Fraserpet" by inadvertence. In the circumstances I have omitted them from the enumeration.

The drawings for Plate No. III were prepared in England by Miss O. F. Tassart; all the other drawings were made at Dehra Dun by Mr. J. B. Singh.

ENUMERATION OF THE SPECIES.

1. **Oxylobus lateralis** Dej. Spec. Gen. I. 1825, p. 400.

Devarbetta, 28-III-1930, 1 ex. found on the ground; Jawalagiri, 25-IV-1930, 1 ex. A common species throughout South India and Ceylon.

2. **Oxylobus exiguus** sp. nov. (*vide* p. 6).

3. **Tachys politus** Motch. Bull. Mosc. 1851. II, p. 509, var. *aspilotus* Andr., Revision of the Oriental Species of the genus *Tachys*, Ann. Mus. Civ. Gen. LI, 1925, pp. 406 and 449.

Fraserpet, 10-II-1930, 1 ex. Very common throughout S. E. Asia, excluding Japan.

4. **Tachys blandus** Andr., in Mission Babault, Carabidae, 1924, p. 85, t. 1, f. 8.

Fraserpet, 10-V-1930, 1 ex. Fairly common throughout India.

5. **Tachys salemus** sp. nov. (*vide* p. 6).

6. **Tachys fumigatus** Motch. Bull. Mosc. 1851. II, p. 509.

Fraserpet, plot 3, 20-XII-1930, 1 ex. One of the commonest species in the East, found throughout S. E. Asia and the Malay Archipelago.

7. **Anthia sexguttata** F. Syst. Ent. 1775, p. 236.

Devarbetta, March 1930, 1 ex. Common throughout the plains of India. I did not see this specimen.

8. **Amblystomus indicus** Nietn. Ann. Mag. Nat. Hist. (3). II. 1858, p. 428.

Uduparani, 28-1-1930, 3 ex. taken at light. A common insect, described from Ceylon and widely spread also in Southern India. H. W. Bates mentions as other localities Chota Nagpur, Burma, and Indo-China, while Mr. T. G. Sloane gives Australia: these identifications appear to require confirmation.

9. **Amblystomus punctatus** Bates. Ann. Mus. Civ. Gen. XXXII. 1892, p. 335.

Jawalagiri, plot 14, 2-III-1931, 1 ex. Fairly common throughout Central and Southern India, Ceylon, and Burma.

10. **Amblystomus** sp.

Fraserpet, plots 1, 3 and 6, 10-VI-1930—22-V-1931, 5 ex.

11. **Amblystomus** sp.

Fraserpet, plots 2, 4 and 6, 21-VI-1930—17-IX-1930, 6 ex.

12. **Amblystomus** sp.

Fraserpet, plot 6, 10-IX-1930, 1 ex. Of the seven species of *Amblystomus* described by Motchulsky, none has yet been satisfactorily identified. The descriptions are generally futile, and, before new species are described, it seems desirable to wait until his type specimens are available for examination.*

13. **Abacetus submetallicus** Nietn. Ann. Mag. Nat. Hist. (3). II. 1858, p. 177.

Fraserpet, 10-II-1930, 1 ex. Fairly common throughout India, Ceylon, Burma, and Indo-China.

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* Since the above was written I have had the opportunity of seeing Motchulsky's types of this genus, and some observations on them will be found in Trans. Ent. Soc., Lond. **1933, pp. 6** *et seq.*

14. **Colpodes** sp. nov.

Fraserpet, plots 1 and 6, 21-26-XI-1930, 2 ex., in very poor condition. The genus has almost a world-wide distribution in the tropics, and S. E. Asia, particularly the Malay region, is very rich in species.

15. **Brachinus sordidus** sp. nov. (*vide* p. 7).

16. **Omphra atrata** Klug Jahrb. Ins. 1834, p. 72. (?)

Uduparani, 28-I-1930, 1 ex., which does not quite agree with the typical form. Bengal, Central Provinces, and Madras, but probably more widely distributed.

17. **Orthogonius femoralis** Chaud. Bull. Mosc. 1848. I. p. 99.

Jawalagiri, plot 8, 2-VI-1930, 1 ex. Confined to Southern India.

18. **Orthogonius** sp. nov.

Aiyur, plot 19, 21-X-1930, 1 ex., in poor condition. The species of this genus are found in termites' nests.

HOLCODERUS. Key to the Indian and Singhalese species (*vide* p. 8).

19. **Holcoderus fissus** sp. nov. (*vide* p. 9).

20. **Holcoderus carinatus** sp. nov. (*vide* p. 10).

21. **Holcoderus superbus** sp. nov. (*vide* p. 10).

22. **Coptodera transversa** Schm. Goeb. Faun. Col. Birm. 1846, p. 54.

Aiyur, 16-VII-1930, 1 ex. Not apparently common, but widely distributed in India, Ceylon, Burma, Indo-China, and the Malay region.

23. **Dromius capnodes** sp. nov. (*vide* p. 11).

RISOPHILUS. Key to the species found in India, Ceylon, and Burma (*vide* p. 12).

24. **Risophilus euproctoides** Bates. Ann. Mag. Nat. Hist. (5). XVII. 1886, p. 209. [Plate II, fig. 3.]

Fraserpet, plots 1, 2, 3, 4, 6 and 7, 25 ex.; Jawalagiri, plots 8, 10, 11, 12 and 14, 9 ex.; Aiyur, plots 16, 19 and 21, 8 ex. Specimens were found practically throughout the year. The species was described from Ceylon, and has also been met with in the Nilgiri Hills.

25. **Risophilus beesoni** sp. nov. (*vide* p. 15).

26. **Risophilus gardneri** sp. nov. (*vide* p. 16).

27. **Risophilus ochroides** sp. nov. (*vide* p. 17).

28. **Calleida splendidula** F. Syst. Eleuth. I. 1801, p. 184.

Aiyur, 3-IV—23-V-1930, 2 ex.; Denkanikota, 28-V-1930, 1 ex. (a variety). Common throughout S. E. Asia, excluding Japan.

29. **Parena nigrolineata** Chaud. Bull. Mosc. 1852. I, p. 44.

Aiyur, 16-V-1930, 1 ex.; Fraserpet, plot 2, 20-XII-1930, 1 ex. Fairly common throughout S. E. Asia, including Southern China and Japan.

30. **Pentagonica ruficollis** Schm. Goeb. Faun. Col. Birm. 1846, p. 48.

Fraserpet, 29-VII-1930, 1 ex. Not common, but widely spread through S. E. Asia and through the Malay Archipelago to Australia; there is, however, no record of its occurrence in China or Japan.

31. **Pentagonica venusta** sp. nov. (*vide* p. 17).

LEBIA. Illustrations of the species found in India, Ceylon, and Burma (Plate III).

32. **Lebia campania** sp. nov. (*vide* p. 20).

33. **Lebia ephippiata** sp. nov. (*vide* p. 20).

34. **Lebia lunigera** sp. nov. (*vide* p. 19).

35. **Lebia ocellata** sp. nov. (*vide* p. 18).

36. **Lebia dichroma** Andr. Spol. Zeyl. XII, 1923, p. 249. [Plate III, fig. 1.]

Aiyur, 10-12-VI-1930, 2 ex. Occurs rather sparsely through India and Ceylon.

Oxylobus exiguus sp. n. [Plate I, fig. 4.]

Length : 11 mm. Width : 3 mm.

Head wide and rather flat, frontal impressions short but deep, diverging behind, front a little uneven, some coarse punctures at sides behind, neck constriction fairly deep at sides only, eyes moderately prominent ; labrum bisetose, the median lobe projecting forward beyond the lateral lobes, clypeus bidentate in front, the median part with a deep semi-circular depression on each side, clypeal suture fairly deep. *Prothorax* quadrate, as long as wide, and only a little wider than head, base somewhat rounded, apex widely emarginate, front angles a little rounded, sides nearly parallel, slightly emarginate, with two setae on each side in front ; median line fine, deeper close to base, basal channel deep, the foveae obsolete, lateral channel rounding front angle, within which is a deep rounded pore, transverse impression fairly deep and a little crenulate. *Elytra* as wide as prothorax, rather less than twice as long as wide, epipleura coarsely punctate ; 8-striate, striae very deep, dorsal ones with closely placed rounded punctures, 1, 2 and 5 free at base, 3 joining 4, 7 and 8 lying together in the marginal channel, 7 visible only towards apex ; intervals forming rounded costae, 1 and 3 slightly wider than the others, 5 and 6 somewhat carinate along inner margin, 7 very narrow and carinate throughout, but not nearly reaching apex, 3 with a pore not far from apex. Prosternum rather sparsely punctate in front, metepisterna coarsely punctate ; ventral segments coarsely punctate, chiefly at sides, a shallow longitudinal depression in front, just behind the mesocoxae, and a much deeper one on the middle of the apical segment.

This species, the smallest at present known in the genus, is allied to *O. lirifer* Andr., but the head, apart from the impression noted above, is smooth and even, the neck constriction slighter, the puncturation less ; the sides of the prothorax are parallel and the transverse impression is deeper ; on the elytra the striae are narrower, with smaller punctures in them, the intervals more nearly equal, 3 with a much smaller pore.

Madras : North Salem, Aiyur, 26-I-1931, 1 ex. " underground ".

Tachys salemus sp. n. [Plate I, fig. 6.]

Length : 3-3·2 mm.

Black, joints 1-4 of antennae, palpi, legs, and two fairly large spots on each elytron ferruginous to flavous, joints 5-11 of antennae fuscous.

Head with duplicated frontal furrows, the inner pair shorter than the outer, eyes prominent, mentum without pores, antennae stout but not moniliform, joint 2=3. *Prothorax* convex, a half wider than long, base a little wider than apex, sides rounded in front and sinuate at a little distance from base, hind angles right with a distinct carina ; basal sulcus deep, rather indistinctly crenulate, interrupted on each side of the central pore with which the fine median line terminates. *Elytra* short and convex, border forming a scarcely perceptible angle at shoulder ; two faintly crenulate dorsal striae, 1 reaching apex and a little longer than 2 in front, where both terminate not far in front of the first pore, 2 extending a little way behind the second pore, 3 when viewed sideways just visible between the two pores, 8 deep throughout, striole on middle of elytron, the pore within it and half way along it, dorsal pores on stria 3, at a third and three-fifths. No microsculpture. Prosternum sulcate, metasternal process sharp, with an arcuate groove behind it.

Very nearly allied to *nannodes* Andr., but a little larger and longer, the apical joints of the elytra fuscous, the spots on the elytra much more distinct ; the head and prothorax hardly differ, though the basal sulcus of the latter is not so deeply impressed on each side of the central pore ; the elytra are slightly, though evidently longer, the dorsal striae faintly arcuate, instead of straight, the vestige of 3 fainter and visible only between the pores.

MADRAS : North Salem, Jawalagiri, 15 and 18-III-1930, 2 ex. ♀♀

Brachinus sordidus sp. n. [Plate I, fig. 5.]

Length : 10 mm. Width : 4·2 mm.

Ferruginous, the elytra and venter black, joints 5-11 of antennae, lateral borders of prothorax, and metepisterna infuscate, legs flavous.

Body winged and covered with a fairly dense yellowish pubescence. *Head* with the frontal foveae moderately deep, finely and irregularly striate at sides, eyes large and prominent, antennae long, stout, reaching middle of elytra, last joint of palpi truncate at apex, vertex nearly smooth, surface elsewhere finely and not closely punctate, with some larger punctures on each side behind. *Prothorax* cordate, barely wider than head and only an eighth wider than long, base a little narrower than apex, sides rounded in front, strongly contracted behind and sinuate at a fourth from base, front angles somewhat rounded, hind ones right but not very sharp, projecting faintly laterally ; median line fine in the middle, deeper at extremities, basal foveae rounded, rather shallow, surface rather closely punctate. *Elytra* convex, a little more than twice as wide as prothorax, about a third longer than wide, strongly contracted in front and widest at apical third, shoulders not rounded away, sides rounded, apex with a fairly deep re-entrant angle, the pale membranous margin without either long setae or any appreciable fringe of minute hairs ; striae very vaguely punctate, intervals a little raised but not costate, the surface very finely, though not very closely, asperate-punctate. Microsculpture very fine and isodiametric, clear on the elytra, indistinct elsewhere. Prosternum densely covered with long hairs; metepisterna long and narrow.

In size and shape very like *B. suturellus* Chaud., but the elytra are uniformly black, instead of blue with a red suture, the prothorax is longer and a little more contracted behind, the elytral intervals less raised.

MADRAS: North Salem, Uduparani (*N. C. Chatterjee*), 28-I-1930, 1 ex. "on wing" (hind legs wanting). UNITED PROVINCES: Dehra Dun (*H. G. Champion*), 1 ex. It seems possible that the type specimen has been labelled "Madras" by inadvertence, and that both specimens came from Dehra Dun.

Key to the Indian and Singhalese species of **Holcoderus.**

1 (8) Elytra with 3 pores on interval 3, none on 5; colour of upper surface chiefly black, metallic green or aeneous.

2 (5) Prothorax with the median line bordered; elytra subconvex, with a tooth on each side at apex opposite stria 2.

3 (4) Head impunctate; elytra with very large dorsal pores, uniformly aeneous (Ceylon) . . . . . . *praemorsus Chaud.*[1]

4 (3) Head punctate; elytra with small dorsal pores, purplish, with the sides metallic green (South India and Ceylon) . . . . . *fissus* sp. n.[2]

5 (2) Prothorax with the median line unbordered; elytra rather flat, without teeth at apex.

6 (7) Prothorax finely and sparsely punctate, a carina running along each side within the border; elytra with the two front pores very large. Length 8·5 mm. (South India) . . . *carinatus* sp. n.[3]

7 (6) Prothorax conspicuously punctate, without lateral carinae; elytra with small dorsal pores. Length about 6·5 mm. (North India) . . . *aeripennis* Andr.[4]

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[1] Ann. Soc. Ent. Belg. XII. 1869, p. 153.

[2] *See* p. 9.

[3] *See* p. 10.

[4] Ann. Mag. Nat. Hist. (10). VII. 1931, p. 519.

8 (1) Elytra with 5 very small pores on interval 3, 2 on interval 5; colour of upper surface brilliant, that of elytra formed by concentric elliptical rings of alternate violet and cupreous green (South India) . . *superbus* sp. n.[1]

Holcoderus fissus sp. n. [Plate I, fig. 1.]

Length : 6·5-7 mm.

Piceous, upper side black with faint purplish reflections, elytral intervals 6-8 covered by a metallic green stripe, which towards apex extends to interval 9 and the inner intervals.

Head moderately convex, frontal impressions short and shallow, bounded externally on each side by a fine carina, which curves round behind to the back of the eye, neck constriction obsolete, labrum and clypeus impunctate, elsewhere finely and rather sparsely punctate, eyes large and fairly prominent, antennae slender, just reaching base of prothorax. *Prothorax* convex, subquadrate, a little wider than head and quite a third wider than long, base produced backwards at middle, sides with a narrow reflexed border, straight in front and behind, an angle at a third from apex, where there is a pore and seta, another at front angle, and a third just before hind angle, where there is a slight indentation in the border, hind angles sharp but a little obtuse ; median line wide and fairly deep, with a wide border, hind transverse impression and the rounded basal foveae fairly deep, surface—except that of median line—rather densely punctate. *Elytra* rather flat, a fourth wider than prothorax and three-fourths longer than wide, shoulders very square, only slightly dilated behind, truncate and tri-emarginate at apex, an obtuse tooth on each side opposite the end of stria 2 ; striae moderately deep, finely punctate, the punctures disappearing on 1-3 towards apex, a small pore on each side of scutellum, intervals a little convex, 7 narrower than the rest and subcostate, 3 with two large pores at a fourth and a half, adjoining stria 3, a third and much smaller one near apex, adjoining stria 2, surface subsericeous. Microsculpture isodiametric throughout, the meshes larger and more conspicuous on the elytra than on the head and prothorax. Proepisterna coarsely punctate ; metepisterna elongate ; last ventral segment finely and sparsely punctate and pubescent, with two marginal setae on each side (♀) ; claws with 3 or 4 small denticulations on each side.

MADRAS : North Salem, Uduparani, 31-V-1930, 1 ex. (type). CEYLON : Horawapotana (*G. M. Henry*—Colombo Mus.), 1 ex. ; Peradeniya, 26-VIII-1910 (Indian Mus.), 1 ex. All the specimens are apparently ♀♀.

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[1] *See* p. 10.

Holcoderus carinatus sp. n. [Plate I, fig. 3.]

Length : 8·5 mm.

Black, upper surface aeneous, the head and prothorax much darker than the elytra ; palpi, base of antennae, and legs more or less ferruginous.

Head wide, frontal impressions subrugose, deep in front, bounded by a carina on each side, neck constriction moderate, deeper at sides, surface finely and sparsely punctate, nearly smooth on vertex, eyes rather flat, antennae fairly stout. *Prothorax* convex, subcordate, a little wider than head, a fourth wider than long, sides with a narrow reflexed border, straight in front, slightly sinuate before base, subangulate at a third from apex, lateral setae as in *superbus* (middle and hind setae abraded), hind angles right but a little rounded, somewhat reflexed ; median line wide but not bordered, pointed in front, basal foveae deep, a well marked carina running on each side from near front angle parallel with sides to a third from base, a fovea on each side of disk a little before middle, surface finely and sparsely punctate. *Elytra* rather flat, two-thirds wider than prothorax, and as much longer than wide, a little compressed at a third from base and thence slightly dilated, apex truncate and bi-emarginate ; punctate-striate, both striae and punctures shallow on disk, fairly deep at sides and behind, stria 7 as in *superbus* ; intervals slightly convex on disk, more convex at sides, 7 carinate at middle, 3 with three conspicuous pores, surface rather shiny, with a few minute irregular punctures, transversely depressed behind base. Microsculpture of elytra consisting of fine transverse lines, forming very wide meshes ; on the prothorax the meshes are similar, but finer and fainter ; on the head they are isodiametric but hardly visible. Underside very finely and sparsely punctate, the pro-episterna more coarsely punctate ; metepisterna long and narrow ; last ventral segment sparsely pilose, with two marginal setae on each side (♀) ; claws with 3 denticulations towards base on each part.

COORG : Fraserpet, 17-V-1930, 1 ex. (♀).

Holcoderus superbus sp. n. [Plate I, fig. 2.]

Length : 9 mm.

Black beneath, upper surface brilliant ; head and prothorax cupreous-green, with violet patches, elytra with an oval purple patch on disk (longer axis longitudinal), surrounded by alternate elliptical rings of violet and cupreous-green.

Head wide, frontal impressions short but fairly deep, bounded on each side by a carina, which disappears behind the eye, neck constriction slight, surface smooth, a few small punctures behind vertex, eyes large and fairly prominent, antennae slender. *Prothorax* convex, subcordate, barely wider than head, a third wider than long, base slightly produced at middle, bordered, sides with a narrow reflexed border, rounded in front, but slightly angulate at a third from apex, sinuate behind, a seta on front angle, and a few small hairs close to it on front margin, a second seta at a third from apex, and a (presumably setiferous) pore on the hind angle, which is sharp, right, and somewhat reflexed ; median line wide but not bordered, pointed in front, front transverse impression at sides, hind impression, and basal foveae all moderately deep, last-named continued forward, nearly parallel with sides, to join the front impression, surface finely and indistinctly punctate. *Elytra* moderately convex, a fourth wider than prothorax, nearly twice as long as wide, shoulders square, sides parallel but slightly compressed behind shoulders, apex truncate, bi-emarginate and also with a small re-entrant angle at middle ; punctate-striate, lightly on disk, more deeply at sides and apex, stria 7 curving round behind the others to apex ; intervals only moderately convex, even at sides, 3 with five pores, 5 with two pores, both on front half (only one visible in the co-type), surface rather shiny. Microsculpture of elytra isodiametric, conspicuous, none on head or prothorax. Underside very finely and sparsely punctate and pubescent ; proepisterna coarsely punctate ; metepisterna elongate ; last ventral segment (♂ ♀) with two marginal setae on each side ; claws with 3 or 4 denticulations on the middle of each part.

COORG : Fraserpet, Plot 6, 3-XII-1930, 1 ex. ♀. MADRAS : Nilambur, Elenjeri (*S. K. Pillai*), 18-V-1925, 1 ex. ♀ (type) ; Nilgiri Hills (*H. L. Andrewes*—my collection), 1 ex. ♂. Although the Nilambur example is a ♀, I have made it the type because the other two are such poor specimens.

Dromius capnodes sp. n. [Plate II, fig. 6.]

Length : 4·25-5 mm.

Piceous, underside variable and often pale ; head and prothorax dark brown, the latter rather lighter at sides and base ; palpi and antennae ferruginous ; legs flavous.

Head small, the surface minutely punctate, frontal foveae short and shallow, a slight fovea on each side of vertex, eyes not very prominent, antennae submoniliform, reaching rather beyond base of elytra. *Prothorax* convex, a fourth wider than head and as much wider than long, base truncate, much wider than apex, front angles rounded, sides narrowly bordered, a little reflexed, explanate behind, rounded in front, only faintly contracted and equally faintly sinuate behind, a seta on hind angle, none in front, hind angles right; median line fine, hind transverse impression and basal foveae moderately deep; surface minutely punctate, with a few transverse wrinkles. *Elytra* flat, subquadrate, three-fourths wider than prothorax, a half longer than wide, apex truncate, basal border reaching stria 2; striae shallow, finely and indistinctly punctate, intervals nearly flat, 3 with a single pore near apex, 7 with half a dozen pores, adjoining stria 6. Microsculpture very distinct, the meshes isodiametric on head and elytra, slightly transverse on average on the prothorax. Last dorsal segment emarginate on each side; last ventral segment a little emarginate at middle and in the ♀ with a deep longitudinal depression, ♂ with 2 marginal setae, ♀ with 3 on each side, the outermost in both sexes longer than the inner ones; claws with 4 denticulations on each side.

Very similar in colour to *D. orthogonioides* Bates, but much smaller, the labial palpi pointed, not obliquely excavate-truncate at apex; the prothorax is narrower, its sides slightly sinuate behind, the elytral striae very shallow.

COORG: Fraserpet, plots 1, 2, 3 and 6, 31-X- 24-XII-1930, 3 ex. MADRAS: North Salem, Noganur, 23-V-1930, 2 ex. (incl. type); Aiyur, plots 15, 17, 18, 19 and 20, II-XI-1930, 17 ex.; Jawalagiri, plots 8 and 12, 11-VI, 1-IX, and 15-XI-1930, 4 ex. MYSORE: Chikkaballapura (*T. V. Campbell*—my coll.), 1 ex.

Key to the species of **Risophilus** *found in India, Ceylon and Burma*

1 (28) Elytra with two, usually conspicuous, dorsal pores on interval 3.
2 (15) Sides of prothorax not, or only gently sinuate behind, the hind angles projecting very little, if at all, laterally.
3 (6) Prothorax not contracted behind, widest at base, upper surface piceous
4 (5) Upper surface glabrous, elytra rather flat, nearly twice as long as wide, uniformly piceous (Ceylon) . . *fuscus* Motch.[1]
5 (4) Upper surface sparsely pilose, elytra convex, only a half longer than wide, piceous but with a pale apical border (Madras) . . . . . . *macellus* Andr.[2]

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[1] Etudes Ent. VIII. 1859, p. 28, t. 1, f. 2.
[2] Ann. Mag. Nat. Hist. (9). XII. 1923, p. 454.

6 (3) Prothorax contracted behind, not wider at base than in front.

7 (14) Elytra moderately dilated behind, the shoulders square, or at least evident, marginal channels of normal width.

8 (13) Elytra moderately convex, more than a half longer than wide, the striae at least moderately impressed, antennae pale.

9 (10) Elytra with intervals 7 to 9 much narrower at base than the inner intervals, head with a deep fovea at each side of front, head and prothorax brown, elytra ferruginous, with a dark shoulder stripe on each side (Ceylon) . . . . *melleus* Bates.[1]

10 (9) Elytra with approximately equal intervals (9 narrower), head not deeply foveolate.

11 (12) Elytra with deep punctured striae, which, like the dorsal pores, are darker than the surrounding surface, colour dirty yellow, length 5-6 mm. (North East India, Burma, Indo-China, Formosa) . . . *luridus* Schm. Goeb.[2]

12 (11) Elytra with the striae and dorsal pores not differing in colour from the surrounding surface, colour variable, from ferruginous with two pale spots on each elytron, to uniform piceous, length 4-4·5 mm. (Southern India and Ceylon) . . . *euproctoides* Bates.[3]

13 (8) Elytra convex, a half longer than wide, the striae very lightly impressed, joints 4 to 11 of antennae and upper surface piceous (Madras) . . *psilus* Andr.[4]

14 (7) Elytra strongly dilated behind, the shoulders rounded away, the marginal channels explanate, disk ferruginous, margins brown (Ceylon) . *repandens* Walk.[5]

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[1] Ann. Mag. Nat. Hist. (5). XVII. 1886, p. 208.
[2] Faun. Col. Birm. 1846, p. 35.
[3] Ann. Mag. Nat. Hist. (5). XVII. 1886, p. 209.
[4] Ann. Mag. Nat. Hist. (9). XII. 1923, p. 455.
[5] Ann. Mag. Nat. Hist. (3). III. 1859. p. 51.

15 (2) Sides of prothorax strongly sinuate near the hind angles, which project on each side as a sharp tooth.

16 (21) Prothorax widest at base, the hind angles projecting far on each side as a very sharp tooth.

17 (18) Sides of prothorax faintly rounded in front, colour piceous, elytra dark ferruginous, clouded round scutellum and towards apex, length 5 mm. (Coorg) . . . . . . *beesoni* sp. n.[1]

18 (17) Sides of prothorax moderately rounded in front, colour flavous, head and prothorax darker, elytra with the suture and a post-median fascia piceous, length 4 mm.

19 (20) Elytra with intervals 1 and 2 on each side, also 3 near base and a fairly deep post-median fascia, generally reaching sides, piceous (Sikkim, Burma) . . . . . . *suturalis* Schm. Goeb.[2]

20 (19) Elytra with the suture and a post-median fascia piceous, both stripe and fascia shortened at their extremities (Burma, Indo-China) . . *annamensis* Bates.[3]

21 (16) Prothorax not wider at base than in front.

22 (23) Prothorax with its sides very gently rounded, hind angles obtuse, but sharp, and projecting very little laterally, elytra black with a pale stripe on each shoulder, length 5 mm. (Coorg) . . . . . . *gardneri* sp. n.[4]

23 (22) Prothorax with its sides moderately rounded, hind angles right, projecting laterally.

24 (25) Elytra black with a small pale spot on each close to apex, length about 5 mm. (Kumaon) . . . . *himalayicus* Andr.[5]

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[1] *See* p. 15.

[2] Faun. Col. Birm. 1846, p. 34.

[3] Ann. Soc. Ent. Fr. 1889, p. 284. Probably only a colour variety of *suturalis*.

[4] *See* p. 16.

[5] Ann. Mag. Nat. Hist. (9). XII. 1923, p. 688.

25 (24) Elytra ferruginous with a dark pattern, length 4-4·5 mm.

26 (27) Elytra with a sutural and two lateral dark stripes on the pale background, a dark fascia just behind middle uniting them (Dehra Dun, Burma, Indo-China, Java, Sumatra) . . *signifer* Schm. Goeb.[1]

27 (26) Elytra with a dark sutural stripe, not reaching extremities, and a dark crescent behind, the whole forming a kind of spear-head (Madras, Burma, Borneo) . . . . *hamatus* Schm. Goeb.[2]

28 (1) Elytra with more than two dorsal pores on interval 3, interval 5 also bearing dorsal pores.

29 (32) Elytra with rounded shoulders, deep striae, a rough surface, and very deep dorsal pores, their colour ferruginous or brown, with a dark spot at each side and a pale one at apex.

30 (31) Elytral interval 3 with six or seven pores, 5 with three to five pores, colour mainly brown (Ceylon) . *catenatus* Bates.[3]

31 (30) Elytral interval 3 with three pores, 5 with three or four pores, colour mainly ferruginous (Ceylon) . . *intermedius* Bates.[4]

32 (29) Elytra with square shoulders, fine striae, and a smooth surface, colour flavous, with only a small vague apical dark spot, interval 3 with four pores, 5 with two or three pores . *ochroides* sp. n.[5]

Risophilus beesoni sp. n. [Plate II, fig. 4.]

Length : 5 mm.

Piceous : elytra dark ferruginous, with a vague cloud round scutellum and another larger cloud on disk behind ; palpi, antennae, and legs pale ferruginous.

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[1] Faun. Col. Birm. 1846, p. 35.
[2] Faun. Col. Birm. 1846, p. 35.
[3] Ann. Mag. Nat. Hist. (5). XVII. 1886, p. 208.
[4] Ann. Mag. Nat. Hist. (5). XVII. 1886, p. 208.
[5] *See* p. 17.

Head convex, smooth, neck deeply constricted, frontal foveae short but moderately deep, a slight rounded fovea on each side of front, eyes prominent, antennae reaching basal fourth of elytra, mentum with a long sharp tooth and a seta on each side of it at base. *Prothorax* a fifth narrower than head, as wide as long, base the widest point, its sides oblique, much wider than apex, sides narrowly bordered, gently rounded in front, strongly sinuate at a sixth from base, front seta at a fifth from apex, where there is a faint tooth on the border, hind seta on the angle, hind angles sharp, right, reflexed, projecting far laterally; median line and transverse impressions all rather shallow, surface rather vaguely transversely striate. *Elytra* moderately convex, elongate-ovate, shoulders narrow but evident, apical truncature faintly emarginate on each side, more than two and a half times wider than prothorax, rather more than a half longer than wide, basal border extending inwards to a point opposite stria 3; striae moderately impressed, vaguely crenulate, intervals a little convex, 3 with two pores, not far from base and apex respectively, surface impunctate. The meshes of the microsculpture are isodiametric on head and elytra, a little transverse on prothorax. Ventral surface sparsely setulose, apical segment more shortly and closely, with two marginal setae on each side (♀); claws very strongly toothed.

Not much like any other species known to me, but distinguishable from those found in India by its comparatively large size, colour, wide head and elytra, and narrow prothorax.

Coorg: Fraserpet, 7-V-1930, 1 ex. ♀.

Risophilus gardneri sp. n. [Plate II, fig. 1.]

Length: 5 mm.

Head and prothorax ferruginous, the latter with a dark lateral border; palpi, antennae, legs, and underside (sometimes darker at sides) flavous; elytra black, with the lateral channels and a humeral vitta on each, covering intervals 4-6 at base, bending a little inwards behind, and disappearing at a half, dull yellow.

Head as in *R. beesoni*, but with less prominent eyes. *Prothorax* also a fifth narrower than head and as wide as long, but as wide close to apex as at base, the sides nearly straight, but rounded close to front angles and sinuate close to base, hind angles a little obtuse, though sharp, and not projecting so far laterally, impressions and surface similar, *Elytra* elongate-ovate, relatively longer and narrower than *beesoni*, two and a half times as wide as prothorax, nearly two-thirds longer than wide, striae and dorsal pores similar, intervals a little flatter. Microsculpture, underside, and legs similar, but there is a depression on the middle of the last ventral segment.

Coorg: Fraserpet, 7-V and 2-XI-1930, 2 ex. ♀♀.

Risophilus ochroides sp. n. [Plate II, fig. 2.]

Length : 5·5 mm.

Flavous : head and prothorax, apical joints of antennae, and tarsi ferruginous ; lateral borders of prothorax, suture of elytra (narrowly), and a small vague spot towards apex of each elytron, on intervals 5-7, more or less piceous.

Head convex, smooth, neck moderately constricted, frontal foveae deep, rounded, more or less joined by a median impression behind them, a rounded fovea on each side of front, eyes only moderately prominent, antennae reaching basal fourth of elytra, mentum with a very sharp tooth. *Prothorax* cordate, as wide as head and a little wider than long, widest at a fourth from apex, base, which is very oblique at sides, barely wider than apex, sides with a narrow microscopically setiferous, reflexed border, rounded in front, but slightly angulate at the widest point, where there is a setiferous pore on the border, sinuate close to base, hind angles somewhat obtuse and not very sharp, projecting laterally, with the hind pore and seta on the angle ; median line and transverse impressions moderately developed, some vague puncturation on the basal area and near hind angles, disk faintly transversely striate. *Elytra* rather flat, subquadrate, slightly dilated behind and widest at apical third, twice as wide as prothorax, not quite two-thirds longer than wide, some microscopical setae visible on the narrow, but rather square shoulders, apical truncature barely emarginate on each side, basal border extending inwards to a point opposite stria 3 ; striae fine, though clearly impressed, impunctate, intervals nearly flat, 1 very narrow, 3 with four pores, 5 with 2 pores (sometimes 3), surface impunctate. Microsculpture of the elytra formed by rather faint isodiametric meshes, practically none visible on head or prothorax. Sides of metasternum and venter sparsely setulose ; apical ventral segment rather more closely pubescent, with one marginal seta on each side in the ♂, two in the ♀ ; in the ♂ this segment is deeply depressed at middle and so deeply emarginate as to be almost bilobed, the depression extending to the fifth segment, a seventh segment visible in the emargination. Claws with the denticulation shorter than usual.

COORG : Fraserpet, plots 1, 6 and 7, 4-III-1930—25-II-1931, 3 ♂♂ and 1 ♀ (without head). UNITED PROVINCES : Dehra Dun, Kaluwala, 1 ex. (my collection).

Pentagonica venusta sp. n. [Plate II, fig. 5.]

Length : 5-5·5 mm.

Ferruginous : elytra black, intervals 1, 8 and 9, shoulders, and legs flavous ; palpi, joint 1 of antennae, disk of head, disk of prothorax, and middle of both femora and tibiae usually more or less infuscate.

Head rather large, a vague transverse impression across front between the front supra-orbitals, eyes very large and prominent, neck constriction deep, antennae fairly stout, reaching a little beyond base of elytra. *Prothorax* pentagonal, convex, a fifth wider than head, four-fifths wider than long, base slightly produced at middle, apex faintly emarginate, bordered, front angles rounded, sides reflexed, angulate at middle, a large pore on the angle, rounded on front half, then straight, but sinuate before the produced base; median line fine but distinct, transverse basal impression deep, surface smooth, basal area vaguely rugose. *Elytra* convex, oval, two-thirds wider than prothorax, two-fifths longer than wide, base emarginate, apex truncate and slightly bi-emarginate, the outer angles rounded; striae rather shallow, vaguely punctate, intervals slightly convex, 3 with three dorsal pores. Microsculpture isodiametric throughout and very distinct, the meshes much finer on head and prothorax than on elytra.

Only two other eastern species are known with a similar elytral pattern, *viz.*, *horni* Dup. from Ceylon, distinguished by having intervals 2 and 7 also flavous, and *suturalis* Schaum from China. The latter species is very closely allied, but in it the head is black and on the elytra only the sutural interval and margin are pale; the sides of the prothorax are sinuate at and not before the produced base, the elytra are relatively longer and rather more finely striate.

COORG: Fraserpet, plot 4, 27-X-1930, 1 ex. (type). MYSORE: Nandidrug (*T. V. Campbell*—my collection), 1 ex. MADRAS: South Mangalore (*J. C. M. Gardner*—For. Res. Inst.), 22-V-1930, 1 ex.; Nilgiri Hills, Kallar, 1,000 feet, November (*H. L. Andrewes*—my collection), 1 ex. BOMBAY: Belgaum (*H. E. Andrewes*), "at light" during the rains, 1886, 1 ex. CEYLON: Peradeniya (Ind. Mus.), 1 ex.

Lebia ocellata sp. n. [Plate III, fig. 11.]

Length: 6-6·55 mm. Width: 3 mm.

Ferruginous, head and disk of prothorax sometimes darker, elytra with a common, black, rounded spot just behind middle, covering the 3 or 4 inner intervals on each side.

Head with very slight frontal foveae, a rounded pore at each end of clypeal suture, eyes prominent, palpi short and slender, antennae rather stout, reaching basal fourth of elytra, surface nearly smooth, but with a few minute punctures and vague rugae. *Prothorax* convex, a fifth wider than head, two-thirds wider than long, base produced at middle, with a distinct though obtuse angle on each side, front angles rounded away, sides moderately explanate and a little reflexed, strongly rounded in front, nearly straight behind, widest at a third from base, front seta on the explanate area at a fourth from apex, hind one on the obtuse hind angle; median line fine, hind transverse impression rather deep in front of the produced middle of base, surface finely rugose-striate. *Elytra* ovate, moderately convex, twice as wide as prothorax, a little more than a half longer than wide, widest at apical third, apex truncate, the outer angles of the truncature rounded; striae very deep, hardly visibly crenulate, intervals strongly convex, 3 with two pores, at a third and three-fourths respectively, surface impunctate. Microsculpture isodiametric throughout and very distinct. Venter punctate and pubescent; mesotibiae ♂ with a nick on inner side near apex; joint 4 of tarsi bilobed, claws with 4 denticulations on each part.

Very similar to *L. monostigma* Andr., but larger, the ground colour darker, but with a similar black spot on the elytra. Head and prothorax similar, but in the Bornean type of *monostigma* the eyes are less prominent, the elytra longer, less convex, and less dilated behind. In *monostigma* there are two dorsal pores on interval 3, placed as in *ocellata*; in the original description only one is mentioned. The two forms are possibly only local races of one variable species.

MADRAS: North Salem, Jawalagiri, plot 9, 21-X and 17-XII-1930, 2 ex. ♂ ♀.

Lebia lunigera sp. n. [Plate III, fig. 18.]

Length: 4-5 mm. Width: 2-2·5 mm.

Ferruginous to flavous, parts of head, prothorax, and venter sometimes, a small region round scutellum usually infuscate, elytra with a piceous, horse-shoe-shaped mark (convex behind) on apical half, extending outwards on each side to stria 5, sometimes 6.

In form and colour very much like *L. ocellata*, just described, but even the large specimens are much smaller, and the elytra are marked with a dark crescent instead of a spot. *Head* similar. *Prothorax* with median part of base less produced behind and the emargination on each side very obtusely angulate, the sides more contracted in front and less so, or not at all, behind, so that the widest part is at or close to the hind angles, which are hardly more than right. *Elytra* shorter, only three-fourths wider than elytra and a fourth longer than wide, the striae much less deep and with slightly more evident crenulation, the intervals only moderately convex. Microsculpture similar. Venter rather sparsely punctate and pubescent; only a minute incision on the inner margin of the ♂ mesotibiae, but joint 4 of the tarsi is similarly bilobed and the denticulations on the claws are unusually long.

MADRAS: North Salem, Jawalagiri, plots 10 and 13 (1 ex. each), 26-IV—10-XI-1930, 11 ex., and Aiyur, 23-V-1930, 1 ex.; Nilgiri Hills, Kallar, 1,000 feet, Nov. (*H. L. Andrewes*—my collection)., 1 ex. BENGAL: Khargpur (*R. Hodgart*—Indian Mus.), 17-30-VIII-1930, 1 ex.

CEYLON: Horawupotana (*G. M. Henry*—Colombo Mus.), 14-X-1924, 1 ex.; Anuradhapura, low country (*N. Annandale*—Indian Mus.), 13-20-X-1911, 1 ex.

Lebia ephippiata sp. n. [Plate III, fig. 5.]

Length: 4·75-5·25 mm. Width: 2·2-2·4 mm.

Flavous, head and disk of prothorax sometimes infuscate, elytra with a narrow zigzag piceous band just behind middle, extending outwards on each side to about stria 8, produced somewhat both backwards and forwards on intervals 1-2, and a little less on interval 6.

Smaller and a little paler than *L. ocellata*, though almost exactly similar in form, the dark marking on the elytra strikingly different. Head and prothorax similar, but the latter is a little narrower, only a half wider than long; the elytra are a little shorter, only three-fourths wider than prothorax and rather less than a half longer than wide, the striae a little less deep and the intervals slightly less convex. Microsculpture, underside, and legs similar, but the nick on the inner side of the ♂ mesotibiae is a very slight one.

MADRAS: North Salem, Jawalagiri, 17-VII—11-XII-1930, 9 ex., and Aiyur, 25-V-1930, 1 ex.

Lebia campania sp. n. [Plate III, fig. 13.]

Length: 4·75-5·5 mm. Width: 2·25-2·75 mm.

Ferruginous, joints 4-11 of the antennae fuscous; elytra with a black band from a little in front of middle to a sixth from apex and extending outwards on each side to stria 9, a subtriangular extension in front, covering the first three intervals on each side and ending in a blunt point half way between the band and the base, hind margin extending furthest back on intervals 2-4.

Smaller than *L. ocellata*, and nearly similar in form, but the pattern on the elytra is entirely different. Head similar; prothorax with sharper, almost rectangular, hind angles and the middle of base more produced; elytra evidently shorter, less than twice as wide as prothorax and not much more than a fourth longer than wide, the striae less deep and the intervals less convex. Microsculpture, underside, and legs similar.

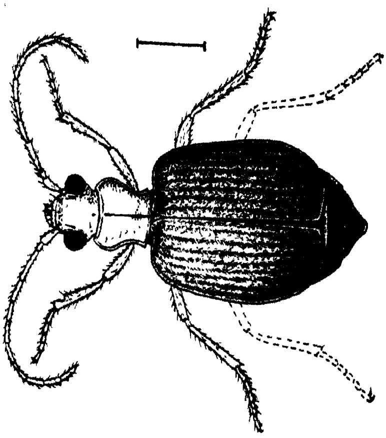
Very near the North Indian *L. baconi* Chaud., but, judging by the author's figure, with the black band on the elytra less deep, the pale area at base being more extensive; in *baconi* the pale area extends backwards to only a fifth from base, and the black median extension of the band nearly reaches base and is truncate in front. It seems probable that both *baconi* and *campania* are only colour varieties of *L. basalis* Chaud., another North Indian species, but an examination of the types and a study of all the Indian species are necessary, before this can be decided.

MADRAS : North Salem, Aiyur, 10-X-1930, 1 ex. ; Nilgiri Hills, Kallar, 1,000 feet, Nov. (*H. L. Andrewes*), 1 ex., and (*A. K. Weld Downing*) 1 ex., both in my collection ; Foot of Palni Hills, Tope, 500 feet, at light, 22-23-IX-1922 (*S. W. Kemp*—Ind. Mus.), 1 ex. BOMBAY : Khandesh (*T. R. D. Bell*—my collection), 1 ex. ; Surat, 6-V-1904 (Pusa collection), 1 ex. CENTRAL PROVINCES : Hoshangabad, Rahatgaon (*S. N. Chatterjee*), 1 ex. BENGAL : Chapra (*Mackenzie*—my collection), 1 ex.

EXPLANATION OF PLATE I.

Fig. 1. Holcoderus fissus sp. nov.
Fig. 2. Holcoderus superbus sp. nov.
Fig. 3. Holcoderus carinatus sp. nov.
Fig. 4. Oxylobus exiguus sp. nov.
Fig. 5. Brachinus sordidus sp. nov.
Fig. 6. Tachys salemus sp. nov.

Plate I.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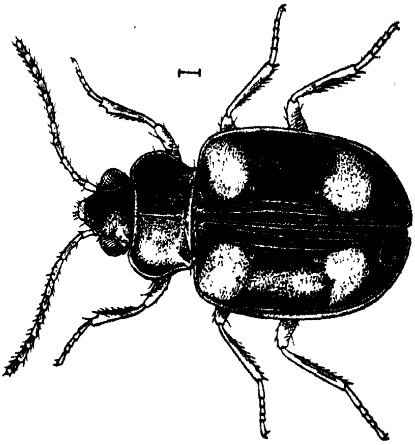
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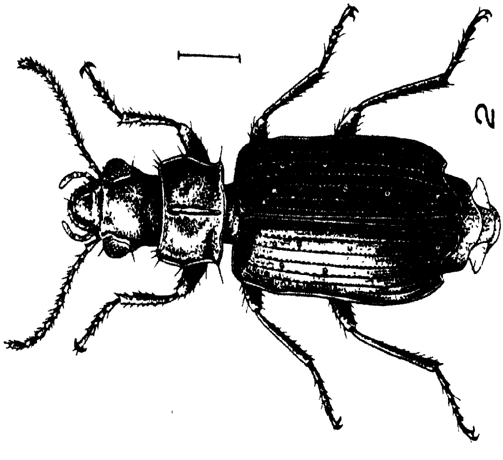
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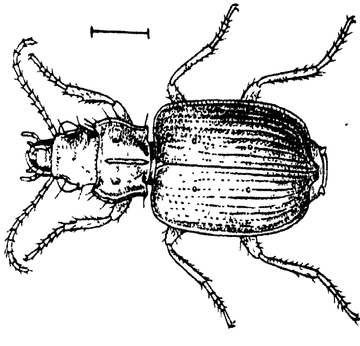
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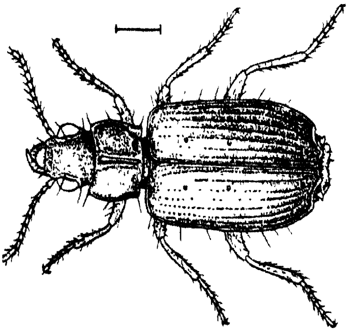
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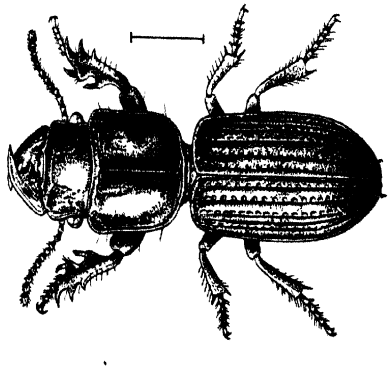
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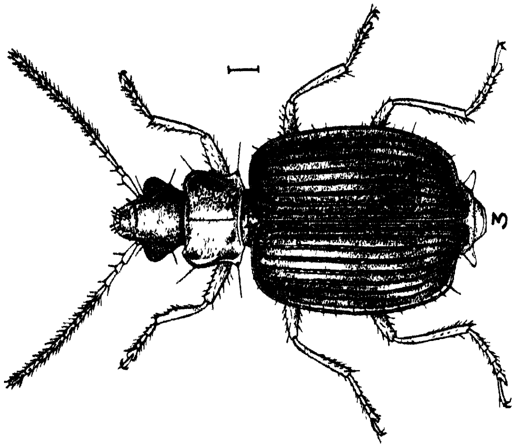
EXPLANATION OF PLATE II.

Fig. 1. Risophilus gardneri sp. nov.
Fig. 2. Risophilus ochroides sp. nov.
Fig. 3. Risophilus euproctoides Bates.
Fig. 4. Risophilus beesoni sp. nov.
Fig. 5. Pentagonica venusta sp. nov.
Fig. 6. Dromius capnodes sp. nov.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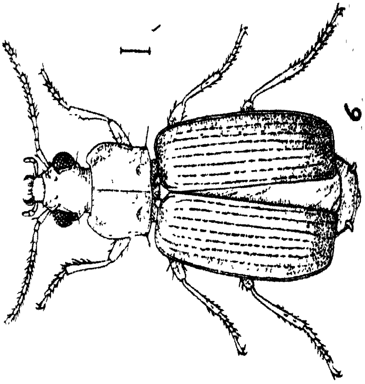
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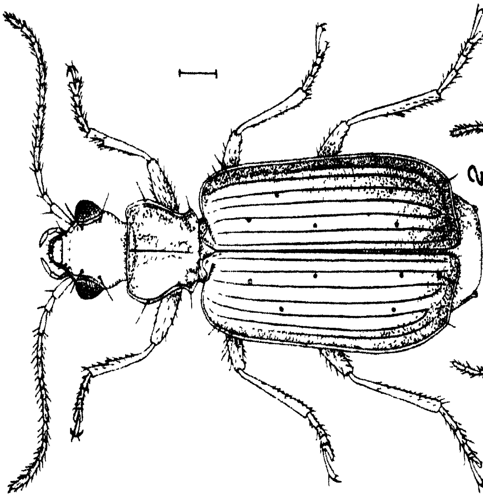
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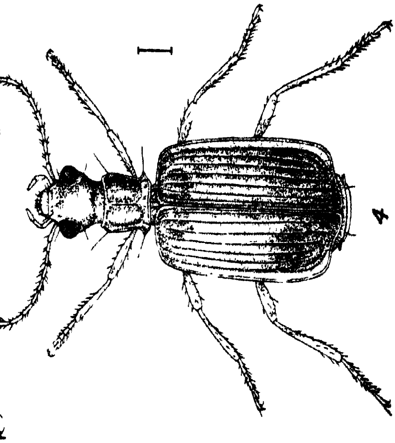
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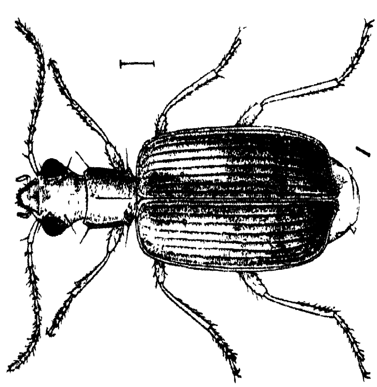
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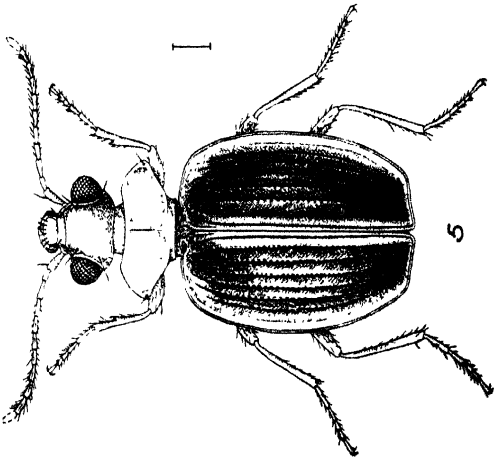
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J. B Singh del.

EXPLANATION OF PLATE III*.

Fig. 1. Lebia dichroma Andr., Spol. Zeyl. XII. 1923, p. 249.
Fig. 2. Lebia aglaia Andr., Trans. Ent. Soc. Lond. 1930, pp. 10 and 44.
Fig. 3. Lebia circumdata Schm. Goeb., Faun. Col. Birm. 1846, p. 44.
Fig. 4. Lebia calycophora Schm. Goeb., Faun. Col. Birm. 1846, p. 44.
Fig. 5. Lebia ephippiata sp. nov.
Fig. 6. Lebia decora Chaud., Mon. des Lebiides (I), Bull. Mosc. 1870. ii, p. 150, t. 1, f. 7.
Fig. 7. Lebia gressoria Chaud., Mon. (I). p. 223, t. 1, f. 46.
Fig. 8. Lebia tau Schm. Goeb., Faun. Col. Birm. 1846, p. 45.
Fig. 9. Lebia karenia Bates, Ann. Mus. Civ. Gen. XXXII. 1892, p. 426.
Fig. 10. Lebia monostigma Andr., Spol. Zeyl. XII. 1923, p. 250.
Fig. 11. Lebia ocellata sp. nov.
Fig. 12. Lebia baconi Chaud., Mon. (I). p. 150, t. 1, f. 6.
Fig. 13. Lebia campania sp. nov.
Fig. 14. Lebia basalis Chaud., Bull. Mosc. 1852. I. p. 43 ; *id.* Mon. (I). p. 149, t. 1, f. 5.
Fig. 15. Lebia boysi Chaud., Bull. Mosc. 1850. I. p. 70 ; *id.* Mon. (I). p. 222, t. 1, f. 33.
Fig. 16. Lebia exsanguis Bates, Ann. Mag. Nat. Hist. (5). XVII. 1886, p. 209.
Fig. 17. Lebia sellata Schm. Goeb., Faun. Col. Birm. 1846, p. 45.
Fig. 18. Lebia lunigera sp. nov.

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* In these illustrations black represents that colour in all except No. 1, where it represents dark blue. All the figures have been drawn from type specimens, cotypes, or examples compared with types, except Nos. 6, 7, 12, 14 and 15 which are taken from Plate I of Chaudoir's Monograph.

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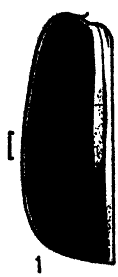
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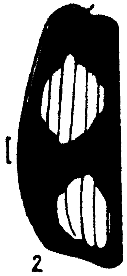
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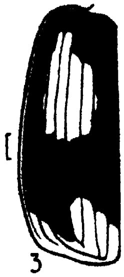
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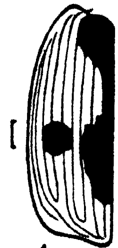
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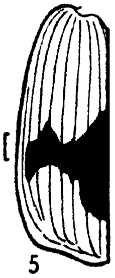
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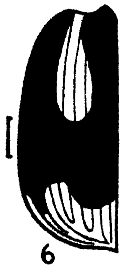
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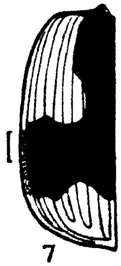
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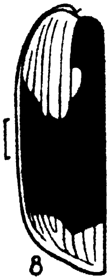
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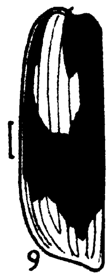
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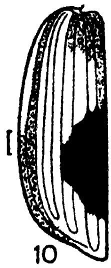
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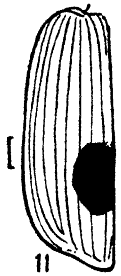
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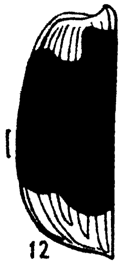
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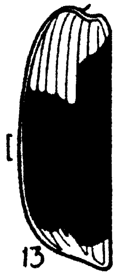
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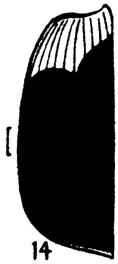
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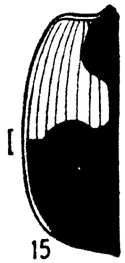
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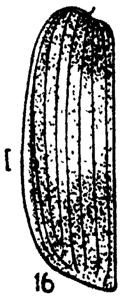
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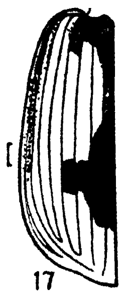
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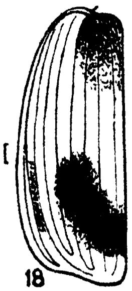
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INDIAN FOREST RECORDS

Vol. XVIII] 1933 [Part VI

ENTOMOLOGICAL INVESTIGATIONS ON THE SPIKE DISEASE OF SANDAL (9).

Neuroptera.

BY

Dr. NATHAN BANKS,

Cambridge, Mass., U. S. A.

[The neuropterous insects obtained in the Forest Research Institute Survey of the insect fauna of sandal (*Santalum album* Linn.) that are dealt with in the present Record are mainly predators, which frequent foliage and bark of trees in their early stages and feed on small caterpillars, plant-lice and leaf-hoppers (Aphidae, Psyllidae, etc.). A consideration of their abundance with reference to the occurrence of their prey is deferred until the species of insects destroyed by them have been identified and analysed.

The localities mentioned in this paper are :—

COORG : North Coorg Forest Division, within five miles of Fraserpet, elevation about 2770 feet, Sample Plots, Nos. 1 to 7.

MADRAS : North Salem Forest Division ; within four miles of Aiyur, elevation about 2850 feet, Sample Plots, Nos. 15 to 21 ; Jawalagiri, elevation about 3050 feet, Sample Plots, Nos. 8 to 14.

For further details of the collecting stations of the Survey *see* Indian Forest Records, Vol. XVII, Part IX.—C. F. C. B.]

HEMEROBIIDAE.

1. **Berotha insolita** Walker.

Fraserpet, 18-I-31 (Plot 3).

2. **Lekrugeria lineata** Navas.

Jawalagiri, 2-XII-30 (Plot 8).

3. **Micromus australis** Hagen.

Fraserpet, 14-XII-30 (Plot 3); Jawalagiri, 13-I-31 (Plot 8), 26-XI-30 and 14-I-31 (Plot 9), 17-I-31 (Plot 12), 11 and 12-I-31 (Plot 13); Aiyur, 24-II-30, on unspiked sandal, 7-XII-30 (Plot 15), 29-XII-30 (Plot 16), 27-I-31 (Plot 17), 24-I-31 (Plot 21).

4. **Micromus nilghiricus** Navas.

Fraserpet, 30-XI-30 (Plot 3), 27-X-30 (Plot 4), 31-XII-30 (Plot 6), 1-I-31 (Plot 7); Aiyur, 18-XI-30 (Plot 7).

5. **Notiobiella viridinervis** Banks.

Aiyur, 15-VIII-30 (Plot 15).

MANTISPIDAE.

1. **Mantispa indica** Westwood.

Fraserpet, 20-IV-31 (Plot 4), 3-XI-30, 17-V-31 (Plot 3).

2. **Mantispa alicante** Banks.

Aiyur, 20-X-30 (Plot 18), 2-XI-30 (Plot 15).

3. **Mantispa femoralis** sp. nov.

Head pale, face with vertical black stripe, a black band back of antennae and another across middle of vertex; antennae black, basal two joints pale; pronotum dark brown on each side, yellowish through the middle above, the enlarged part with a pale transverse mark; mesonotum dark, with a yellow band across in front and the scutellum yellow, metascutellum also yellow, pleura dark, with two vertical pale streaks; coxae dark, front femora brown, outer side partly pale, mid and hind femora with a broad dark streak on the under side almost making a band, mid and hind tibiae dark at base. Abdomen mostly dark, some of the middle segments banded at base with yellow. Wings hyaline; venation almost wholly dark brown, a few veins at base pale yellow, stigma dark brown elongate. Structure, size, and venation very similar to *M. indica*, of which it may be a colour variety.

Type: Coorg: North Coorg Division, Fraserpet, 14-V-31 (Plot 7); also Fraserpet, 21-V-31 (Plot 7).

Differs from *M. indica* by dark stigma, dark streak on femora, and dark bases of tibiae.

4. **Mantispilla torquilla** Newman.

Fraserpet, 22-II-30, 10-IV-30 ; Aiyur, 22-II-30, on unspiked sandal, N. C. C., 9-XII-30, 18 and 25-I-31, 8-III-31 (Plot 15), 29-VII-30, 6-I-31 (Plot 17), 25-IV-31 (Plot 21).

CHRYSOPIDAE.

1. **Ankylopteryx candida** Fabricius.

Jawalagiri, 14-IV-30, on unspiked sandal, N. C. C.

2. **Nothochrysa aequalis** Walker.

Jawalagiri, 14-V-31 (Plot 11).

3. **Chrysopa khandalina** Navas.

Jawalagiri, 30-V-31, 15-VII-30, 15-IX-30, 19-VIII and 2-IX-30 (Plot 9), 31-VIII-30 (Plot 14), Aiyur, 23-II-30, 23-VII-30, 15-XII-30, 25-I-31 (Plot 15), 31-XII-30 (Plot 18), 20-II-31 and 29-VIII-30 (Plot 20), 17-I and 25-IV-30 (Plot 21).

4. **Chrysopa schmitzi** Navas.

Jawalagiri, 17-I-31, (Plot 12), 27-IV-30, on spiked sandal, N. C. C. ; Aiyur, 3-I-31, 12-III-30, on unspiked sandal, N. C. C., 15-III-30, on unspiked sandal, N. C. C., 25-I-31 (Plot 15), 23 and 30-XII-30 (Plot 17), 28-I-31 (Plot 18).

5. **Chrysopa virgestes** Banks.

Fraserpet, 16-XII-30 (Plot 5) ; Jawalagiri, 13-I-31 (Plot 8) ; Aiyur, 12 and 14-III-30, 16-XII-30, 28-XII-30 (plot 15), 10-XII-30 (Plot 18).

6. **Chrysopa alcestes** Banks.

Aiyur, 24-II-30, 23-XI-30, 30-XI-30 (Plot 15), 26-I-31 (Plot 16), 10-XIII-30 (Plot 18).

7. **Chrysopa orestes** Banks.

Aiyur, 4-XII-30 (Plot 19), 14-X-30 ; Jawalagiri, 14-IV-30, on unspiked sandal, N. C. C., 15-I-31.

8. **Chrysopa cymbele** sp. nov.

Pale yellowish ; in some a red mark across the face near labrum ; antennae beyond the third joint black ; and out for about one-third its length, from thence pale ; basal joint and palpi unmarked. Wings greenish, venation pale, unmarked. Wings rather slender, acute at tip; the gradates of fore wings in parallel rows, 6 and 7, the outer row rather nearer to margin than to the inner row. Divisory veinlet ends at or near the cross-vein above, second cubital cell as long as third, at base above close to the radius; hind wings with veins unmarked, about 4 to 6 gradates in each row.

Length fore-wing 13 mm., width 4 mm.

Type: MADRAS: North Salem Division, Aiyur, 20-IX-30 (Plot 16); also Aiyur, 22-II-30, on unspiked sandal, N. C. C., 9-III-30, 20-IX-30 (Plot 16), 17-VIII-30 (Plot 17), 7-VIII-30 (Plot 21); Jawalagiri, 15-VII-30, 29-VII-30 (Plot 9).

It must be near *C. rocasolanoi* Navas which has the antennae dark on basal part, but that species is said to have a mark on the basal joint of antennae, several of the veins are dark, and moreover Navas figures the cells near base of fore wing showing the second cubital cell small and remote from the radius; his figure of the pronotum is also too long for *C. cymbele.*

ASCALAPHIDAE.

1. **Suphalomitus verbosus** Walker.

Fraserpet, 24-V-30.

Total: 18 species of Neuroptera.

MGIPC—M—III-2-68—23-6-33—500.

INDIAN FOREST RECORDS

Vol. XVIII] 1933 [Part VII

ENTOMOLOGICAL INVESTIGATIONS ON THE SPIKE DISEASE OF SANDAL (10).

*MELASIDAE AND ELATERIDAE (COL.).

BY

E. FLEUTIAUX,

Nogent-sur-Marne, France.

[The fifty species of Melasidae and Elateridae listed in this paper were taken in the course of the Forest Research Institute Survey of the insect fauna of sandal, *Santalum album* Linn. in the districts of Coorg and North Salem, Madras, South India. The beetles abundantly frequent the foliage of sandal in both healthy and spiked condition, but there is no evidence on which they can be included among the suspected vectors of spike disease. Thirty-three species occur in Coorg and thirty-two in North Salem.

The localities mentioned are :—

COORG : North Coorg Forest Division, within five miles of Fraserpet, elevation about 2,770 feet, Sample Plots, Nos. 1 to 7.

MADRAS : North Salem Forest Division ; within four miles of Aiyur, elevation about 2,850 feet, Sample Plots, Nos. 15 to 21 ; Denkanikota, elevation about 2,900 feet ; Jawalagiri, elevation about 3,050 feet, Sample Plots, Nos. 8 to 14 ; Noganur, elevation about 2,900 feet; Uduparani, elevation about 3,090 feet.

For further particulars of the collecting stations of the survey see Indian Forest Records, Vol. XVII, Part IX . . C. F. C. B.]

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* NOTE.—This paper is published in French at the author's request.

MELASIDAE.

Gen. **Dromaeolus.**

Kiesenwetter, Nat. Ins. Deutschl., IV, 1858, p. 197.
(Génotype : *Eucnemis barnabita* Villa, 1838.)

1. **D. angustissimus** nov. sp.

7 m/m ½.—Allongé, très étroit, atténué aux deux extrémités ; noir brillant ; pubescence légère, grise sur la moitié antérieure, obscure au delà. Tête densément ponctuée, fortement carénée au milieu ; crêtes surantennaires réunies au milieu, épistome très étroit, subcaréniforme à la base. Antennes noires, ne dépassant pas la base du prothorax ; 3e article plus long que le suivant. Pronotum notablement plus long que large, parallèle, rétréci aux angles antérieurs, deprimé, fortement sillonné au milieu en arrière, peu densément ponctué, plus légèrement en avant. Elytres graduellement atténués, déprimés à la base, de chaque côté de l'écusson, non striés, assez densément et finement ponctués, plus légèrement en arrière. Dessous et pattes noirs.

Ressemble beaucoup à *D. montanus* Fleutiaux, d'Assam ; mais plus étroit ; épistome subcaréniforme à la base ; pronotum beaucoup plus long ; élytres non rugueux à la base ; antennes et pattes noires.

Un seul exemplaire.

COORG : Fraserpet, 2-IV-31, plot 7 (1 ex.).

Gen. **Porraulacus.**

Fleutiaux, Ann. Mus. Civ. Genova, 1896, p. 567.
(Génotype : *P. submarginalis* Fleutiaux.)

2. **P. santali** nov. sp.

4 à 4 m/m ½.—Allongé, convexe, atténué en arrière ; noir mat ; pubescence grise sur la moitié antérieure. Tête convexe, très densément ponctuée ; crêtes surantennaires réunies sur la base de l'épistome ; épistome un peu plus étroit en arrière que la crête surantennaire, très élargi en avant ; bord antérieur sinué. Antennes noires, filiformes, ne dépassant pas la base du pronotum ; 3e article plus long que le suivant. Pronotum plus long que large, parallèle, arrondi en avant, convexe, formant un lobe saillant en éperon au milieu de la base, fortement rugueux. Elytres atténués, convexes, fortement rugueux en avant, moins en arrière, distinctement striés à la base seulement. Dessous noir. Propectus à ponctuation forte et serrée ; sillons antennaires assez larges, nettement limités, peu profonds, ponctués, peu éloignés du bord

latéral en avant, le rejoignant en arrière. Métasternum et abdomen finement et densément ponctués. Episternes métathoraciques subparallèles, plus étroits que les épipleures des élytres. Hanches postérieures élargies en dedans ; bord postérieur sinué ; bord externe plus large que les épisternes. Dernier arceau ventral largement comprimé. Fémurs noirs ; tibias bruns ; tarses plus clairs, 4e article dilaté en dessous.

Très remarquable par sa forme étroite et allongée qui le fait ressembler à un *Dromaeolus* ; sa convexité et sa forte rugosité, le distinguent en outre des espèces du genre dejà connues.

COORG : Fraserpet, I-II-31, plots 4, 6 (2 exs.).

Gen. **Balistica.**

Motschulsky, Bull. Natur. Moscou, 1861, 1, p. 116.
(Génotype : *B. picipes* Motschulsky.)

3. **B. picipes.**

Motschulsky, *loc. cit.*; p. 116, t. 9, f. 7—Bonvouloir, Mon. Eucn.; 1872, p. 511, t. 25, f. 7.

Fraserpet, 17-IX-30, plot 6 (1 ex.).

Gen. **Dirhagus.**

Latreille, Ann. Soc. Ent. France, 1834, p. 130.
s.g. *Rhacopus* Hampe, Verh. Zool. Bot. Wien, V, 1855, p. 256.
(Type : *Eucnemis sahlbergi* Mannerheim, 1823—*cinnamomeus* Hampe.)

4. **D. indicus** nov. sp.

7m/m.—Allongé, subparallèle, convexe ; brun rougeâtre ; pubescence jaune légère. Tête superficiellement ponctuée, biimpressionnée entre les yeux ; crêtes surantennaires interrompues sur la base de l'épistome ; épistome plus large en arrière que la crête surantennaire. Antennes ferrugineuses ; 3e article beaucoup plus long que le 4e ; suivants serriformes. Pronotum aussi long que large, légèrement rétréci en avant, largement arrondi au-dessus de la tête, convexe antérieurement, graduellement déclive en arrière, faiblement asillonné au milieu ; ponctuation ombiliquée, serrée ; angles postérieurs brièvement carénés ; crochet de la carène marginale du bord antérieur court. Elytres longs, parallèles, arrondis au sommet, finement et peu densément ponctués, substriés. Dessous de même couleur. Impressions antennaires étroites, lisses, brillantes, parallèles en avant, élargies à la base. Carène latérale entière.

Episternes métathoraciques subparallèles, légèrement plus étroits en avant. Hanches postérieures élargies en dedans. Pattes ferrugineuses.

Ressemble à *D. lewisi* Fleutiaux, du Japon ; pronotum non brusquement déclive en arrière, carène médiale postérieure indistincte ; ponctuation moins serrée, non rugueuse. Elytres plus légèrement striés, plus finement ponctués, non repliés en dessous au sommet. Carène latérale du pronotum entière.

Un seul exemplaire.

Madras : North Salem, Jawalagiri, 22-IV-30.

ELATERIDAE.

Gen. **Adelocera.**

Hyslop, Proc. Un. St. Nat. Hist., 58, 1921, p. 62?.
(Génotype : *Elater ovalis* Germar, 1824.)
Lacon auctores.

1. **A. abrepta.**

Lacon abreptus Candèze, Ann. Soc. Ent. Belgique, 1893, p. 170.
Lacon delesserti Candèze, Elat. nouv., III, 1881, p. 9 (Mém. Soc. Roy. Sc. Liège, 2, IX).

Fraserpet, IV-30 (4 exs.), V-30 (5 exs.), VI-30 (3 exs.), XI-30 (1 ex.) plot 1.

2. **A. pistoria.**

Lacon pistorius Candèze, Ann. Soc. Ent. Belgique, 1893, p. 171.

Fraserpet, IV-V-30 (2 exs.), IV-31 (1 ex.) plot 7.

3. **A. muscosa.**

Lacon muscosus Candèze, Ann. Soc. Ent. Belg., 1893, p. 170.

Fraserpet, 22-V-30 (1 ex.).

4. ? **A. transversa.**

Lacon transversus Candèze, Mon. Elat., I, 1857, pp. 93 et 123 (Mém. Soc. Roy. Sc. Liège, XII).

Aiyur, X-30 (1 ex.) plot 21, I-31 (1 ex.) plot 19 ; Jawalagiri, VI-30 (4 exs.), VII-30 (1 ex.), 8-VIII-30 (1 ex.) plot 12, X-30 (1 ex.) plot 11, XI-30 (8 exs.) plots 9, 11, 12, 13, 14, 17, 18,

5. A. lustrata.

Lacon lustratus Candèze, C. R. Soc. Ent. Belgique, 1890, p. 149.

Jawalagir. V-30 (2 exs.), VII-30 (1 ex.).

Gen. Brachylacon.

Motschulsky, Et. Ent., VII, 1858, p. 60.
(Génotype : *B. microcephalus* Motschulsky.)

6. B. microcephalus.

Motschulsky, *loc. cit.*—*Lacon trifasciatus* Candèze, Elat. nouv., 1864, p. 10 (Mém. Acad. Belgique, XVII).

Fraserpet, 7-VI-30 (1 ex.).

7. B. sparsus.

Lacon sparsus Candèze, Révis. Mon. Elat., 1874, pp. 49 et 85 (Mém. Soc. Roy. Sc. Liège, 2, IV).

Fraserpet, 17-VIII-30 (1 ex.) plot 3 ; Jawalagiri, 8-VI-30 (1 ex.).

Gen. Pericus.

Candèze, Mon. Elat., I, 1857, pp. 20 et 167 (Mém. Soc. Roy. Sc. Liège, XII).
(Génotype : *P. nitidus* Candèze.)

8. P. sanguinolentus.

Candèze, Ann. Soc. Ent. Belgique, 1893, p. 172.

Fraserpet, 11-II-30 (1 ex.).

Gen. Trachylacon.

Motschulsky, Et. Ent., VII, 1858, p. 61.
(Génotype : *T. fulvicollis* Motschulsky.)

9. T. santali nov. sp.

5½ à 7 m/m.—Ovale ; noir ; pubescence bicolore ; blanche et serrée sur les côtés du pronotum et formant quelques petites mouchetures légères et une petite tache très apparente sur chacun, avant l'extrémité ; rousse sur les élytres, plus claire à la base et formant une tache de chaque côté de la suture au delà de la moitié. Tête arrondie en avant, déprimée au milieu, densément ponctuée. Pronotum aussi long que large parallèle, subdilaté sur les bords, anguleusement rétréci dans le tiers antérieur, très convexe au milieu, brusquement déclive sur les côtés, densément ponctué ; bords externes ondulés ; angles postérieurs aplatis, aigus, non divergents. Ecusson pentagonal, plan, incliné, ponctué. Elytres subélargis jusqu'à la moitié, notablement atténués au delà, conjointement ou isolément arrondis au sommet, densément ponctués, très légèrement substriés. Dessous et pattes noirs ; tarses brunâtres.

Ressemble beaucoup à *T. variegatus* Schwarz ; mais de taille plus grande ; peut-être faudrait-il le rapporter à l'énigmatique *T. fulvicollis* Motschulsky, 1858.

Madras : North Salem, Aiyur, V-30 (1 ex.), IX-30 (1 ex.) plot 18, XI-30 (1 ex.) plot 19.

Gen. **Campsosternus.**

Latreille, Ann. Soc. Ent. France, 1834, p. 141.
(Génotype : *Elater auratus* Drury, 1773—*fulgens* Olivier, 1790.)

10. **C. duponti.**

Hope. Ann. Mag. Nat. Hist., VIII, 1842, p. 454—Idem, Trans. Ent. Soc. London, III, 1843, p. 290—Candèze, Mon. Elat., I, 1857, pp. 342 et 349 (Mém. Soc. Roy. Sc. Liège, XII)—*foveolatus* Germar, Zeitschr. Ent., IV, 1843, p. 103—*iris* Candèze, *loc. cit.*

Aiyur, V-30 (4 exs.), 28-VI-30 (3 exs.) on unspiked sandal, N. C. C.; Jawalagiri, V-30 (2 exs.), 7-VI-30 (1 ex.), VI-30 (3 exs.) on spiked and on unspiked sandal, N. C. C., 13-V-30 (1 ex.) on *Dodonaea viscosa*, N. C. C.; Noganur, 23-V-30 (1 ex.) ; Uduparani, 30-V-30 (2 exs.).

11. **C. latreillei.**

Guérin, Voy. Delessert, Hist. Nat., II, 2, 1843, p. 37—*guerini* Candèze, Mon. Elat., I, 1857, pp. 342 et 351 (Mém. Soc. Roy. Sc. Liège, XII). (nec *latreillei* Germar, 1843).

Denkanikota, 19-VI-30 (1 ex.).

Gen. **Singhalenus.**

Candèze Mon. Elat., II, 1859, pp. 9 et 43 (Mém. Soc. Roy. Sc. Liège, XIV).
(Génotype : *S. taprobanicus* Candèze.)

12. **S. taprobanicus.**

Candèze, *loc. cit.*, p. 44.—Fleutiaux, Ann. Soc. Ent. France, 1905, p. 321.

Fraserpet, 16-IV-30 (2 exs.), V-30 (2 exs.) ; Aiyur, IV-30 (5 exs.), V-3 (80 exs.), VII-30 (1 ex.) plot 21, X-30 (1 ex.) plot 17 ; Jawalagiri, IV-30 (2 exs.), 10-IV-30 (1 ex.) ; Noganur, 26-V-30 (3 exs.) ; Uduparani, 31-V-30 (1 ex.).

13. **S. rubiginosus.**

Candèze, *loc. cit.*, pp. 44 et 45.

Aiyur, V-30 (1 ex.).

Gen. **Adiaphorus.**

Candèze, Mon. Elat., II, 1859, pp. 9 et 47 (Mém. Soc. Roy. Sc. Liège XIV).
(Génotype : *gracilicornis* Candèze.)

14. **A. gracilicornis.**

Candèze, *loc. cit.*, p. 47—Schwarz, Deutsche Ent. Zeitschr., 1901, p. 17.

Fraserpet, IX-30 (1 ex.) plot 6, X-30 (1 ex.) plot 7.

15. **A. ponticerianus.**

Candèze, *loc. cit.*, p. 47, t. 2, f. 4—Fleutiaux, Ann. Soc. Ent. France, 1905, p. 321.

Fraserpet, 14-II-30, (1 ex.) on unspiked sandal, N. C. C., III-30 (1 ex.), IV-30 (3 exs.), 7-VIII-30 (1 ex.) plot 7, 6-IX-30 (1 ex.) plot 2.

Gen. **Heterocrepidius.**

Guérin, Mag. Zool., 1838, p. 23.
(Génotype : *ventralis* Guérin.)

16. **H. alternatus** nov. sp.

10 à 11 m/m.—Allongé, subparallèle ; brun ; pubescence grise, moirée sur le pronotum, plus épaisse sur les interstries pairs des élytres, Tête sillonnée au milieu. fortement et rugueusement ponctuée. Antennes longues, robustes, dépassant la moitié du corps, brun ferrugineux, 2e et 3e articles très courts, globuleux ; suivants plus larges et beaucoup plus longs. Pronotum plus long que large, peu rétréci en avant, sinué latéralement, fortement ponctué, sillonné au milieu en arrière ; angles postérieurs aigus et divergents. Ecusson arrondi en arrière. Elytres plus larges que le pronotum, à peine rétrécis en arrière, arrondis au sommet ; striés-ponctués ; interstries pairs densément pubescents. Dessous et pattes bruns ; tarses plus clairs.

Voisin de *H. contractus* Candèze ; plus robuste, très reconnaissable à la pubescence des élytres plus dense sur les interstries pairs. Je le possède du sud du Mysore, des chasses de H. L. Andrewes.

COORG : Fraserpet, 5-IV-30 (1 ex.).

Gen. **Monocrepidius.**

Eschscholtz, *in* Thom. Ent. Archv ; II, I, 1829, p. 31.
(Génotype : *M. pallipes* Eschscholtz.)

17. **M. tenuis.**

Candèze, Mon. Elat., II, 1859, pp. 190 et 228 (Mém. Soc. Roy. Sc. Liège, XIV). —Fleutiaux, Ann. Soc. Ent. France, 1905, p. 323.

Jawalagiri, V-30 (1 ex.), VI-30 (1 ex.).

18. **M. fuscus** nov. sp.

8 m/m ½.—Allongé, peu convexe ; noir terne ; pubescence rousse. Tête peu convexe, densément ponctuée. Antennes fines, brunes, ne dépassant pas la base du prothorax. Pronotum beaucoup plus long que large, parallèle, arrondi aux angles antérieurs, peu convexe, faiblement sillonné au milieu en arrière, densément et nettement ponctué ; angles postérieurs à peine divergents, aigus, unicarénés ; limites latérales entières, infléchies en avant. Ecusson arrondi, plan, légèrement déclive, finement et densément ponctué. Elytres peu convexes, faiblement arrondis et rétrécis en arrière, striés-ponctués ; interstries plans et finement ponctués. Dessous brunâtre, plus clair sur l'abdomen pattes testacées.

Rappelle *M. monachus* Candèze ; pronotum plus long, plus parallèle ; élytres plus courts ; hanches postérieures plus brusquement élargies en dedans.

Un exemplaire.

COORG : Fraserpet, 3-XI-30 (1 ex.) plot 4.

Gen. **Megapenthes.**

Kiesenwetter, Nat. Ins. Deutshl. IV, 1858, pp. 229 et 353.
(Génotype : *Elater lugens* Redtenbacher, 1842.)

19. **M. modestus.**

Candèze, Mon. Elat., II, 1859, pp. 493 et 507 (Mém. Soc. Roy. Sc. Liège, XIV).

Fraserpet, VI-30 (2 exs.) ; Aiyur, 27-VII-30 (2 exs.) plot 17, 9-VII-30 (1 ex.) ; Jawalagiri, 25-V-30 (1 ex.), 6-VI-30 (1 ex.)

Gen. **Melanoxanthus.**

Germar, Zeitschr. Ent., V, 1844, p. 191.
(Génotype : *Elater melanocephalus* Fabricius, 1781.)

20. **M. melanocephalus.**

Elater melanocephalus Fabricius, Spec. Ins., 1781, p. 272—*Melanoxanthus melanocephalus* Candèze, Mon. Elat., II, 1859, p. 512, t. 7, f. 12—Schwarz, Deutsche Ent. Zeitschr., 1901, p. 17—Fleutiaux, Ann. Soc. Ent. France, 1905, p. 323.

Jawalagiri, 26-VI-30 (1 ex.), Cosmopolite tropical.

21. **M. horni.**

Schwarz, Deutsche Ent. Zeitschr., 1901, p. 26.

Aiyur, 12-VI-30 (1 ex.).

22. **M. lugubris** nov. sp.

6 m/m ½.—Allongé, atténué en arrière, convexe ; noir mat ; pubescence noire. Tête carénée au milieu ; ponctuation forte, serrée, rugueuse. Antennes noires, épaissies vers le bout, ne dépassant pas la base du prothorax. Pronotum beaucoup plus long que large, parallèle, arrondi aux angles antérieurs, convexe, brusquement déclive à la base ; ponctuation forte, serrée, ombiliquée ; angles postérieurs aigus, non divergents. Ecusson triangulaire, perpendiculaire. Elytres moins larges que le pronotum, atténués en arrière. convexes, brusquement déclives à la base ; rugueux, plus fortement en avant, striés-ponctués ; interstries, plans. Dessous et pattes noirs.

Entièrement noir comme *M. granum* Candèze ; beaucoup plus allongé et plus rugueux ; tête carénée au milieu.

Un seul exemplaire.

MADRAS : North Salem, Jawalagiri, 11-V-30 (1 ex.).

23. **M. sanguinicollis.**

Schwarz, Deutsche Ent. Zeitschr., 1902, p. 325.

Aiyur, V-30 (6 exs.), V-31 (1 ex.) plot 20, VI-30 (1 ex.), VI-31 (1 ex.) plot 19, VII-30 (2 exs.), Jawalagiri, VI-30 (1 ex.), VII-30 (1. ex.).

variété **thoracicus** nov.

Bande noire sur le milieu du pronotum n'atteignant pas la base.

COORG : Fraserpet, 17-VII-30 (1 ex.).

24. **M. vitticollis.**

Candèze, Mon. Elat., II, 1859, pp. 512 et 517 (Mém. Soc. Roy. Sc. Liège, XIV). *trivittatus* Schwarz, Deutsche Ent. Zeitschr., 1901, p. 27 ? (*nec. M. vitticolis* Motschulsky, Et. Ent., VIII, 1859, p. 56).

Fraserpet, 7, 27-VI-30 (2 exs.) ; Aiyur, V-30 (3 exs.), VI-30 (1 ex.), VII-30 (1 ex.), VIII-30 (1 ex.) plot 20, 12-VIII-30 (1 ex.) plot 19.

25. **M. andrewesi** nov. sp.

4 m/m. ½.—Ovale, peu convexe ; jaune, tête noire en arrière ; pronotum avec deux bandes longitudinales noires au milieu et une tache oblongue plus petite de chaque côté près du bord externe ; écusson noir ; élytres ornés chacun, au premier quart, d'un trait noir en forme de V, la seconde moitié est presque entièrement noire avec seulement une petite tache jaune près de la suture au dernier quart, une plus grande près du bord un peu au dessous et une autre très réduite tout à fait à l'extrémité. Tête convexe ; ponctuation ombiliquée, serrée. Antennes noires, ferrugineuses à la base et au bout. Pronotum large, rétréci et arrondi en avant ; ponctuation ombiliquée, serrée ; angles postérieurs aigus, carénés, non divergents. Elytres plus étroits que le pronotum atténués en arrière, rugueux, striés-ponctués. Propectus jaune ; métasternum et abdomen noirâtres. Pattes testacé pâle.

Diffère de *M. vitticollis* Candèze, par le pronotum orné de quatre bandes noires et le dessin des élytres différent. Dédié à H. L. Andrewes qui l'a capturé à Anamalai.

COORG : Fraserpet,17-V-30 (1 ex.).

Gen. **Arhaphes**.

Candèze, Mon. Elat., II, 1859, pp. 52 et 98.
(Génotype : *A. diptychus* Candèze.)

26. **A. lineicollis** nov. sp.

5 à 7½ m/m.—Allongé, cylindrique ; noir mat, avec une ligne médiane sur le pronotum et une tache aux épaules, ferrugineuses ; pubescence jaune. Tête déprimée, rugueuse ; bord antérieur transversal. Antennes brunes. Pronotum plus long que large, presque parallèle, très faiblement arrondi latéralement, convexe et densément rugueux ; bord antérieur largement arrondi et légèrement relevé ; angles postérieurs droits, aplatis tout à fait au sommet. Elytres parallèles, arrondis à l'extrémité, rugueux, fortement striés-ponctués. Dessous de même couleur noire, assez fortement et peu densément ponctué ; sutures prosternales à peine distinctes. Hanches postérieures légèrement élargies en dedans. Pattes testacé pâle.

La coloration est assez variable ; elle est parfois d'un brun rougeâtre ; parfois aussi, la tache humérale fait défaut. Ressemble beaucoup à *A. bivittatus* Fleutiaux, mais sa rugosité est moins grossière, plus régulière, plus serrée.

COORG : Fraserpet, V-30 (9 exs.), VI-30 (7 exs.), IX-30 (2 exs.) plots 5, 7, X-XI, (2 exs.) plot 5.

Gen. **Cardiophorus.**

Eschscholtz, *in* Thom. Ent. Archiv, II, 1, 1829, p. 34.
(Génotype : *Elater gramineus* Scopoli, 1763.)

27. **C. albomaculatus** nov. sp.

1 m/m ½.—Elliptique ; noir brillant avec deux taches transversales éburnées sur chaque élytre ; une au premier tiers, plus large en dedans du 4e interstrie au bord externe ; l'autre au tiers postérieur, du 4e au dernier interstrie ; pubescence obscure, grise sur la base du pronotum, celle des élytres et sur les taches. Tête légèrement convexe, arrondie en avant ; ponctuation fine et peu serrée. Premiers articles des antennes noirs (les autres manquent). Pronotum aussi long que large, sinué sur les côtés, arrondi et peu rétréci en avant ; convexe ; ponctuation fine et écartée. Elytres atténués, ponctués-striés ; interstries plans, très finement pointillés. Dessous également noir ; pubescence grise. Limites latérales du pronotum inférieures, non sinueuses, bien marquées, effacées en avant. Ponctuation des propectus large, superficielle, écartée ; fine et plus serrés sur le métasternum, très dense sur l'abdomen. Hanches postérieures sinueuses, modérément élargies en dedans. Pattes noires.

Un seul exemplaire. Ressemble beaucoup à *C. quadrillum* Candèze (type : Almorah) ; mais de forme plus courte ; ponctuation du propectus large, peu marquée et écartée ; taches des élytres transversales, pattes plus noires.

COORG : Fraserpet, 23-IX-30 (1 ex.).

28. **C. pallipes.**

? *Elater pallipes* Fabricius, Mant. Ins. I, 1787, p. 174—Idem, Ent. Syst., 1, 2, 1792, p. 231– Idem, Syst. Eleuth., II, 1801, p. 241– Erichson, Zeitschr Ent., II, 1840, p. 305—Candèze, Mon. Elat., III, 1860, pp. 117 et 171, t. 3. f. 18 (Mém. Soc. Roy. Sc. Liège, XV)—Schwarz, Deutsche Ent. Zeitschr., 1901, p. 18.

Fraserpet, 5-XI-30 (1 ex.) plot 6 ; Uduparani, 28-I-30 (1 ex.) at light.

subgen. *Paracardiophorus.*

Schwarz, Deutsche Ent. Zeitschr., 1895, p. 40.
(Type : *Cardiophorus musculus* Erichson, 1840.)

29. **C. fuscipennis.**

Horistonotus fuscipennis Candèze, Mon. Elat., III, 1860, pp. 247 et 268 (Mém. Soc. Roy. Sc. Liège, XV).

Fraserpet, 14-VI-30 (1 ex.) ; Jawalagiri, 9-VIII-30 (1 ex.) plot 13.

30. C. minutus nov. sp.

3 m/m.—Oblong ; brun noirâtre, extrémité des angles postérieurs du pronotum et deux grandes taches jaunes sur chaque élytre ; une à l'épaule, l'autre à l'extrémité ; pubescence grise. Tête large, peu convexe, arquée en avant ; ponctuation assez grosse, peu serrée. Antennes testacées. Pronotum transversal, convexe ; ponctuation assez grosse et espacée. Elytres légèrement atténués, fortement ponctués-striés ; interstries plans. Dessous noirâtre ; ponctuation grosse et espacée. Limites latérales du pronotum abrégées en avant. Hanches postérieures graduellement élargies. Pattes testacées pâles.

Un seul exemplaire. Plus petit que *C. fuscipennis* Candèze ; noir ; taches jaunes très apparentes sur les élytres ; peu convexe ; pronotum transversal ; ponctuation espacée.

Madras : North Salem, Uduparani, 30-V-30 (1 ex.).

Gen. Dicronychus.

Brullé, Expl. Morée, 1832, p. 138 (nec *Castelnau*, 1840).
(Génotype : *D. obesus* Brullé=? *Elater cinereus* Herbst, 1784.)

31. D. pictipennis.

Cardiophorus pictipennis Schwarz, Deutsche Ent. Zeitschr., 1902, p. 333.

Fraserpet, 15-IX-30 (1 ex.) plot 4 ; Aiyur, 6-XI-30 (1 ex.) plot 19 ; Jawalagiri, IX-30 (1 ex.) plot 9, X-30 (3 exs.) plots 9, 12, 13, XI-30 (1 ex.) plot 10.

32. D. lepidus.

Cardiophorus lepidus Candèze, Ann. Soc. Ent. Belgique, 1893, p. 176.

Aiyur, 12-VI-30 (1 ex.).

33. D. lacertosus.

Cardiophorus lacertosus Erichson, Zeitschr. Ent., II, 1840, p. 316—Candèze, Mon. Elat., III, 1860, pp. 120 et 205 (Mém. Soc. Roy. Sc. Liège, XV)—Fleutiaux, Ann. Soc. Ent. France, 1905, p. 328.

Fraserpet, V-30 (5 exs.), VI-30 (5 exs.), VII-30 (4 exs.), IX-30 (2 exs.), IX-30 (2 exs.) plots 3, 4, II-31 (1 ex.) plot 3 ; Aiyur, I-31 (2 exs.) plots 15, 16, VI-30 (1 ex.), IX-30 (2 exs.) plot 15, X-30 (2 exs.) plot 18, XI-30 (3 exs.) plot 21, XII-30 (5 exs.) plots 18, 20 ; Denkanikota, 18-VI-30 (1 ex.) ; Jawalagiri, VI-30 (4 exs.), IX-30 (2 exs.) plot 10, X-30 (1 ex.) plot 10, XI-30 (2 exs.) plots 9, 12.

variété **bigeminatus.**

Cardiophorus bigeminatus Candèze, Ann. Soc. Ent. Belgique, 1893 p. 176.

Fraserpet, 6-I-31 (1 ex.) plot 5.

34. **D. contemptus.**

Cardiophorus contemptus Candèze, Mon. Elat., III, 1860, pp. 121 et 202 (Mém. Soc. Roy. Sc. Liège, XV)—Fleutiaux, Ann. Soc. Ent. France, 1905, p. 328.

(*nec* Candèze, C. R. Soc. Ent. Belg., 1890, p. 154—Idem, Ann. Soc. Ent. Belgique, 1892, p. 492).

Fraserpet, V-30 (1 ex.).

35. **D. densepunctatus** nov. sp.

6 à 6½ m/m.—Allongé, subparallèle ; noir, avec une bande jaune étroite sur le milieu des élytres, bien apparente à la base, effacée en arrière ; pubescence grise. Tête peu convexe, finement et densément ponctuée ; bord antérieur largement arrondi et étroitement rebordé. Antennes noires, grêles, ne dépassant pas la base du prothorax. Pronotum aussi long que large, sinué sur les côtés, un peu moins large en arrière, convexe, criblé de points serrés bien marqués ; sillons basilaires très courts. Elytres fortement ponctués-striés ; interstries finement chagrinés. Dessous noir. Pattes noires, ferrugineuses aux articulations.

Ressemble à *D. lacertosus-bigeminatus* ; taille plus grande ; bande jaune des élytres moins rapprochée de la suture ; pronotum criblé de points profonds et très serrés ; antennes et pattes noires.

COORG : Fraserpet, 17, 21-V-30 (2 exs.) on unspiked sandal, N. C. C.

MADRAS : Jawalagiri, 13-V-30, (1 ex.) on spiked sandal N. C. C.

36. **D. multus** nov. sp.

7 à 10 m/m.—Allongé, brun noir brillant ; pubescence grise. Tête presque plane, irrégulièrement criblée de points assez gros, arquée et rebordée en avant. Antennes fines, ferrugineuses, ne dépassant pas la base du prothorax. Pronotum aussi long que large arqué sur les côtés, arrondi en avant, redressé en arrière, peu convexe, criblé de points assez serrés ; sillons basilaires bien marqués. Elytres subparallèles, arrondis et rétrécis (au delà de la moitié) fortement striés-ponctués ; interstries pointillés. Dessous de même couleur. Limites latérales du pronotum inférieures, effacées en avant. Pattes ferrugineuses ; griffes fortement dentées.

Ressemble à *D. contemptus* moins étroit ; pronotum moins long, ponctuation plus égale et mieux marquée ; griffes plus fortement dentées.

Fraserpet, VI-30 (1 ex.) ; Aiyur, 11-IX-30 (1 ex.) plot 17 ; Jawalagiri, VIII-30 (1 ex.) plot 12, IX-30 (5 exs.) plot 8, IX-30 (2 exs.) plot 11, X-30 (3 exs.) plot 10, (3 exs.) plot 12, (1 ex.) plot 13.

37. D. **santali** nov. sp.

6 ½ à 7 m/m ½.—Allongé ; brun ferrugineux rembruni sur le dos du pronotum ; pubescence grisâtre légère. Tête convexe arrondie et rebordée en avant, finement et densément ponctuée. Antennes fines, ne dépassant pas la base du prothorax, ferrugineuses à la base, noirâtres au delà. Pronotum aussi long que large, peu rétréci en avant, sinué latéralement, convexe, finement et densément ponctué ; sillons basilaires peu marqués. Elytres convexes, rétrécis en arrière au delà de la moitié, fortement ponctués striés ; interstries plans, finement pointillés. Dessous noirâtre, parfois ferrugineux sur le propectus et sur l'abdomen. Limites latérales du pronotum inférieures, entières. Pattes ferrugineuses ; griffes fortement dentées.

MADRAS : North Salem, Aiyur, X-30 (1 ex.) plot 21, I-31 (1 ex.) plot 20 ; Jawalagiri, IX-30 (1 ex.) plot 10, IX-30 (2 exs.) plot 11, 27-IX-30 (1 ex.) plot 13, IX-30 (1 ex.) plot 14, X-30 (1 ex.) plot 11.

38. D. **tristis** nov. sp.

8 m/m ½.—Allongé, convexe ; noir ; pubescence gris légère. Tête convexe, arquée et rebordée en avant, finement et très densément ponctuée. Antennes grêles, noirâtres, ne dépassant pas la base du prothorax. Pronotum aussi long que large, bombé et élargi en avant, rétréci en arrière, finement et très densément ponctué ; sillons basilaires bien marqués. Elytres subcylindriques, rétrécis et arrondis dans le dernier tiers, fortement ponctués-striés ; interstries convexes et finement ponctués. Dessous noir. Limites latérales du pronotum inférieures, effacées près du bord antérieur. Pattes noirâtres ; griffes fortement dentées.

Se distingue de *D. santali* par sa forme subcylindrique, sa couleur noire, son pronotum bombé et élargi en avant, sa ponctuation mieux marquée.

MADRAS : North Salem, Denkanikota, V, VI-30 (2 exs.).

variété **sanguineus** nov.

6 m/m.—Pronotum sanguin, obscurci sur le dos en avant.

MADRAS : North Salem, Jawalagiri, 5, V-31 (1 ex.).

Gen. **Agonischius.**

Candèze, Mon. Elat., IV, 1863, pp. 284 et 407 (Mém. Soc. Roy. Sc. Liège, XVII).
(Génotype : *A. pectoralis* Candèze.)

39. **A. mirus.**

Candèze, *loc. cit.*, pp. 409 et 412.

Jawalagiri, 1-IX-31 (1 ex.).

40. **A. cardiorhinulus.**

Candèze, *loc. cit.* pp. 410 et 424.

Fraserpet, IV, V-30 (2 exs.) ; Aiyur, III-30 (1 ex.), V-30 (7 exs.), 18-V-30 (1 ex.) on unspiked sandal, N. C. C., V-31 (1 ex.) plot 20, VI-30 (2 exs.), VII-30 (1 ex.) ; Jawalagiri, IV-30 (3 exs.), V-30 (3 exs.) ; Noganur V-30 (4 exs.).

41. **A. prymneus.**

Candèze, *loc. cit.*, pp. 410 et 424.

Fraserpet, 29-V-30 (1 ex.).

42. **A. pumilus.**

Candèze, Ann. Soc. Ent. Belgique, 1893, p. 178.

Aiyur, V-30 (1 ex.), V-31 (1 ex.) plot 15.

43. **A. indicus** nov. sp.

7 m/m ½.—Allongé, bleu-violet foncé métallique ; pubescence noire. Tête à ponctuation espacée. Antennes noires, ne dépassant pas la base du prothorax, comprimés et serriformes à partir du 4e article, élargies vers le bout ; 2e et 3e articles étroits et de même forme, le 3e plus long. Pronotum aussi long que large, rétréci en avant, convexe, ponctué sur le bord en avant, presque lisse en arrière, avec des points espacés extrêmement fins ; angles postérieurs courts, aigus, non divergents. Elytres parallèles arrondis à l'extrémité, convexes, légèrement striés-ponctués. Dessous de même couleur sauf l'abdomen ferrugineux. Pattes noires.

Parfois, seul le dernier arceau ventral est ferrugineux.

Ressemble à *A. indigaceus* Candèze, de Bornéo. Je le possède de Nilgiri Hills (H. L. Andrewes) et le Musée de Dehra-Dun en contient des exemplaires récoltés à Chakata Range, Haldwani, U. P. (S. N. Chatterjee).

COORG : Fraserpet, 12-XI-30 (1 ex.) plot 6.

Gen. **Glyphonyx.**

Candèze, Mon. Elat., IV, 1863, pp. 448 et 451 (Mém. Soc. Roy. Sc. Liège, XVII).
Génotype : *G. gundlachi* Candèze.

44. G. flavidus.

Candèze, *loc. cit.*, pp. 452 et 458.

Fraserpet, 6-VII-30 (1 ex.).

Gen. **Silesis.**

Candèze, Mon. Elat., IV, 1863, pp. 448 et 458.
(Génotype : *S. hilaris* Candèze.)

45. **S. indicus** nov. sp.

5 à 5 m/m ¾.—Allongé, subparallèle : noir brillant ; pubescence grise. Tête convexe, assez fortement et densément ponctuée. Antennes testacées. Pronotum un peu plus long que large, légèrement rétréci en avant, arrondi aux angles antérieurs, convexe, ponctué comme la tête sur les côtés, plus finement et moins densément sur le dos ; angles postérieurs aigus, non divergents, carénés ; sillons basilaires bien marqués. Elytres très faiblement rétrécis en arrière, arrondis au sommet, convexes, striés-ponctués ; interstries finement pointillés. Dessous noir, finement ponctué. Pattes testacées.

Elytres parfois bruns.

Coorg : Fraserpet, IV-30 (2 exs.), V-30 (3 exs.), VI-30 (1 ex.).

Madras : North Salem, Aiyur, XI-30 (1 ex.) plot 20, XII-30 (1 ex.) plot 17.

Gen. **Plectrosternus.**

Lacordaire, Gen. Col., IV, 1857, pp. 224 et 227.
(Génotype : *P. rufus* Lacordaire.)

46. P. rufus.

Lacordaire, *loc. cit.*, pp. 228—Candèze, Mon. Elat., IV, 1863, p. 493, t. 6, f. C—Schwarz, Deutsche Ent. Zeitschr., 1901, p. 18.

Fraserpet, 12, 30-VI-30 (2 exs.).

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INDIAN FOREST RECORDS

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ENTOMOLOGICAL INVESTIGATIONS ON THE SPIKE DISEASE OF SANDAL (11).

THE LIFE-HISTORY AND MORPHOLOGY OF SARIMA NIGROCLYPEATA, MEL.

Fulgoridae (Homopt.).

BY

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INTRODUCTORY.

This paper embodies in part the results of an investigation conducted in North Salem, North Coorg, and Vellore forest divisions, on the entomology of the spike disease of sandal (*Santalum album*), taken up by the writer under the direction of the Forest Entomologist.

The Indian Fulgoridae have been very scantly studied, and with the exception of Misra's work (8) on the sugarcane leaf-hopper, *Pyrilla aberrans*, Kirby, we know very little about the life-history and bionomics of the Fulgoridae of India. From an economic stand point the Fulgoridae must be counted injurious, as all the species so far known, are dependent upon growing plants for their food. Besides being pests of agricultural crops, fulgorids are incriminated in the transmission of various virus diseases.

Indian investigators regard the spike disease of sandal as due to a virus. If the virus of spike disease is insect-borne, a permissible hypothesis is, that the vector is one of the dominant insects of sandal. With regard to the efficiency of the various groups of insects as vectors of virus diseases, Smith (*12; p. 317-318*) writes 'apart from three rather doubtful cases, biting insects (Coleoptera and Orthoptera) seem to be concerned in the dissemination of only three plant viruses, while all the rest are transmitted by sucking insects. Then, as regards sucking insects, in the Thysanoptera there appears to be only one authentic case of virus transmission by thrips with four others in which the connection is not definitely proved.' He further states 'considering the aphididae, these are found to be responsible for the transmission of no less than twenty-seven plant viruses, in which twenty-three species of Aphis are concerned. The Aphididae then are undoubtedly the most efficient insect vectors of plant viruses'. 'Next in efficiency come the Jassidae including Fulgoridae with seven viruses.'

Studies on bionomics, distribution, incidence, and morphology of sandal insects restrict the consideration of the probable vectors of Spike disease to nineteen species of Homoptera, belonging to the families Aphididae, Jassidae, Fulgoridae and Cicadidae; to three species of Curculionidae, to three species of Thysanoptera (thrips); and to one species of Acarina (red spider).

Most of the life-history studies were made during February, 1930, to December, 1931, in the field at Denkanikota, in Hosur Taluk of the Salem district. From January, 1932, work was started in the Insectary provided by the Indian Institute of Science, Bangalore. Transmission experiments were also conducted with some of the selected probable vectors during the 1931-32 season, (April to March), and the results obtained will form the subject of a separate paper.

1. Systematic Position.

Melichar (*6*) has classified the sub-family Issidae into three groups, CALISCELIDAE, HEMISPHAERIDAE, and ISSIDAE, and the third group Issidae is further divided into three sub-groups (*a*) HYSTEROPTERINAE, (*b*) ISSINAE, (*c*) THIONINAE. The genus *Sarima* belongs to the sub-group Thioninae.

2. ECONOMIC STATUS.

This is one of the very common species of Fulgoridae found feeding on both healthy and spiked sandal trees in North Salem, Coorg, and Vellore forest districts of the Madras Presidency, and in the State forest areas lying between Hunsur and Fraserpet, belonging to the Mysore Durbar. No previous record on the bionomics of this species is available. During the course of field work and insectary experiments, it was discovered that the combined feeding of twenty-four adults and nymphs of *Sarima nigroclypeata*, caused the shedding of the entire foliage and the dying-back of the twigs and young shoots of a sandal branch in two months. A suppressed sandal plant at Jawalagiri under sleeve-experiments, was found dead within three months, due to the action of mass feeding by this species. *S. nigroclypeata* is injurious to sandal both as adult and nymph.

As a consequence of the abnormal drain of sap from the plant, this species when feeding on sandal foliage and shoots checks the growth, and if its attack is prolonged and severe the foliage may be shed entirely, the young shoots may be killed back and thus the vitality of the tree reduced. The new flush that comes up after complete leaf-shedding caused by *S. nigroclypeata*, has been observed in certain cases to be short and clustered, but this condition lasts for two to three months only. Like *Petalocephala nigrilinea Walk*, and others this is one of the species responsible for causing the general condition of stagheadedness (*14*) in sandal, seen in the sandal forests of South India.

3. DISTRIBUTION.

Lanouli, Matheran, Bombay; (Melichar). Aiyur, Dasempatti Daverbetta, Hoganackal, Jawalagiri, Muttur, Nognoor, Uduparani, North-Salem Forest Division; Kottur-yelagiri, Vellore Forest Division; Madras; Fraserpet, North Coorg Forest Division; Chamundi Hill, Hunsur, Koppa, Periyapatna, Mysore; (Forest Research Institute).

4. FOOD PLANTS.

This species has been observed to feed and breed on the following plants:—*Albizzia amara, Dodonæa viscosa, Erythroxylon monogynum, Lantana camara, Pterolobium indicum, Santalum album, Scutia indica, Webera corymbosa.*

BIOLOGY.

5. TECHNIQUE FOR THE STUDY OF LIFE-HISTORY.

Considerable difficulty was experienced at first, in rearing the sandal fulgorids, in the building which served as insectary at Denkanikota. After many trials the following method was found to be satisfactory.

These insects did quite well inside tubes of 6″ × 1″, the open end of which was covered with a small piece of muslin. A small succulent sandal shoot with one or two leaves, was introduced inside the tube as food. Owing to the condensation of moisture on the inside of the tube, due to the drying up of the shoot, the food was changed every alternate day during September to January, and daily during other months of the year. No difficulty was experienced in dislodging the insects from the shoots or leaves. A slight shake brought them on to the sides of the tube, after which the old shoot was removed and the insects were carefully transferred to a clean tube with a fresh sandal shoot. Rearing inside tubes had the advantage that the insects could be examined with a hand lens without disturbing them much. Later sleeves 15″ × 9″ and cellophane cages, 14″ in length and 5″ in diameter, supported on thin wire frame, covering a nine-inch-high sandal seedling grown from seed in a pot were used. The diameter of the cage was smaller than the diameter of the pot, and the space between the cage and the rim of the pot was utilised for watering the sandal plant, which did quite well. As the moulted skins are left sticking to the stem, or leaf, or are found on the ground, observations could be easily made and accurate records maintained, without disturbing the insects in any way. In this method, the disturbance caused by the first method in the removal of the various stage nymphs from one tube to another, was avoided. As a check on the work in the laboratory, observations were recorded in the forest. Eggs, nymphs, and adults were sleeved on numerous sandal shoots at Aiyur, Denkanikota and Jawalagiri and their development watched at frequent but definite intervals.

6. HABITS.

The first stage nymph on hatching, moves up and down for a short time over the shoot of sandal, and then selects a spot on the new leaves or on leaf bud; punctures the surface tissue, and begins to suck sap. Third, fourth, fifth stage nymphs, and adults suck sap from both green and suberised shoots; while the first and second stage nymphs feed on the fresh flush of leaves and sprouting leaf buds very rarely on green shoots. Just the tip of the rostrum is inserted inside plant tissues while feeding, the rostrum penetrating at an acute angle. When leaves are not available, the younger nymphs die. The punctures made on shoot and leaf are very minute, almost imperceptible to the naked eye. Adults and nymphs feed on both healthy and spiked sandal, are delicate creatures, and are very active in their movements. They jump about from shoot to shoot, and plant to plant, and when approached move away quickly to the opposite side of a shoot or leaf. When alarmed the adults jump to a height of three feet, and the nymphs about eighteen inches. The flight of the adult is not strong, but it can fly short distances to reach adjoining plants. Adults and older nymphs rest on shoots, while younger nymphs rest on leaves and succulent shoots. The nymphs are provided with a pair of anal brushes, consisting of a number of wax bristles, which are banded black and white. They spread out these brushes fanwise, more particularly when they are about to moult. During the repeated process of spreading, the anal brushes wear out, break, drop off, and only short stumps projecting from the apex of the abdomen are left after a time. The nymphs have also the habit of carrying the anal brushes right over the back, and moving them sideways apparently to scare and drive away an approaching enemy. The products of digestion is a sweet transparent liquid, which is excreted in the form of a fine spray, with the apex of the abdomen tilted upwards. The honeydew occasionally accumulates on surfaces of leaves and shoots in small lumps. When freshly deposited the honeydew imparts a shining appearance to leaves and shoots, which subsequently become sooty black owing to the growth of a mould. This species is not gregarious.

7. COPULATION.

Copulation takes place end to end, the heads of the male and female being away from each other and lasts for two to three hours during the day time. In some cases the period of copulation was found to exceed this time. The female after copulation, wanders over the plant to select a proper site for laying eggs, and the male either remains on the plant or jumps off to another plant. Copulation begins within ten days after the last moult, but may be delayed for more than a fortnight.

8. OVIPOSITION.

The female begins to oviposit within a week of copulation and oviposition is followed by further mating. In captivity *Sarima nigroclypeata* lays eggs by instalments, and the interval between two successive instalments varies from five to seven days. Examination records of sleeved shoots in the forest indicate, that mating and oviposition goes on all round the year; so that females of the older generation may be evipositing, when adults of a new brood are emerging from the last moult.

9. SITE OF OVIPOSITION.

The female oviposits on the bark of shoots, at the axil of leaf and shoot, on the petiole of the leaf, on old and new leaf flush, and also on sprouting leaf buds. The eggs are never deposited inside plant tissue. The eggs are laid singly, rarely in clusters of three or four, distributed all over the branch, and are struck on the surface with a secretion.

10. INCUBATION.

The egg when freshly laid is dull white in color, which gradually becomes pale yellow on the seventh day. The color of the egg changes to mixed pink and yellow on the tenth day, and finally attains a light pink color throughout on the fourteenth day. When about to hatch the pink embryo can be distinctly seen inside the egg shell. The body occupies just three quarters the length of the egg with two dark red spots, the future eyes of the first stage nymph at the cephalic end; the abdominal segments are clearly defined, and the long legs are seen sticking out at the sides.

11. DURATION OF INCUBATION PERIOD.

The shortest time taken for the eggs to hatch was seventeen days in April and June at a mean temperature of 80°F—82°F, while the longest time was of twenty-five days in February—March at a mean temperature of 74°F. The average of nineteen records is of 21·4 days and the mode is of 23 days at a temperature of 68°—82°F, in practically all the months of the year.

12. HATCHING.

The nymph emerges by making a slit at the side of the egg with the help of the third legs, which are provided with toothed trochanters. By rubbing the toothed trochanters against the chorion of the egg from within, a meso-metasternal suture is first made, and is further widened by the spines on the tibia and tarsus of the third legs. The first to come out from the egg are the head and rostrum. By moving laterally and also backwards and forwards, the yolk skin or membrane enclosing these parts, is gradually pushed down the abdomen and the legs till the body is entirely free.

13. DIFFERENT STAGES IN THE LIFE-HISTORY.

The nymph undergoes five moults during an average period of one hundred days and then becomes adult. Collecting on any day of the year on sandal plant, with yield almost all the stages of this species. The time spent in the different stages during the different months of the year is given below.

First Nymphal Stage.

The shortest time taken to moult from the first to the second nymphal stage was fifteen days in June at a mean temperature of 80°F, while the longest time was twenty-four days in January at a mean temperature of 70°F.

One nymph moulted in sixteen days in March at a mean temperature of 76°F, while three transformed in seventeen days during April, June, and July, at mean temperatures of 85°F, 80°F and 78°F respectively. Four individuals moulted in eighteen days at mean temperatures of 80°F, 78°F, 77°F, 70°F during June, July, September and December; and four moulted in nineteen days during February, July, August and December at mean temperatures of 74°F, 78°F, 79°F and 70°F. Four individuals moulted in twenty days during August, October and December at mean temperatures of 79°F, 77°F, 70°F; two moulted in twenty-one days in January, and August, at mean temperatures of 68°F and 79°F; while three moulted in twenty-two days during January, February, and December at mean temperatures of 68°F, 69°F, and 70°F.

The average time of twenty-three records is 19·2 days, and the mode is 18 to 20 days, at mean temperature varying between 70°F to 80°F, in practically all months of the year.

Second Nymphal Stage.

The shortest time taken to transform from the second to third nymphal stage, was fourteen days during February—March, at a mean temperature of 78°F; and the longest time was twenty-four days during December—January, at a mean temperature of 69°F.

Twenty-four individuals, took fifteen to twenty-three days to moult from the second to third stage, at mean temperature varying between 69°F—86°F. The average time of twenty-six records is 19·4 days, and the mode is 19 days, at mean temperature varying between 69°F—86°F, in practically all months of the year.

Third Nymphal Stage.

The shortest time taken to moult from the third to fourth nymphal stage, was sixteen days during April—May, at mean temperature of 82°F—85°F; while the longest time was twenty-three days during March and September, at mean temperature of 75°F and 77°F.

Twenty-two individuals, took seventeen to twenty-two days to transform, at mean temperature varying between 68°F—85°F. The average time of twenty-nine records is 19·9 days, and the mode is 20 days, at mean temperature varying between 68°F—79°F, in six out of twelve months of the year.

Fourth Nymphal Stage.

The shortest time taken to moult from the fourth to fifth nymphal stage, was eighteen days during April—May, at a mean temperature of 86°F; while the longest time was twenty-three days during February, at a mean temperature of 73°F.

Twenty-four individuals, took nineteen to twenty-two days to transform, at mean temperature varying between 70°F—87°F. The average time of twenty-eight records is 20·7 days, while the mode is 20 days, at mean temperature varying between 71°F—86°F, in practically all months of the year.

Fifth Nymphal Stage.

The shortest time taken to moult from the fifth nymphal stage to the adult hopper, was nineteen days in the month of May, at a mean temperature of 86°F; and the longest time was twenty-four days during August—September, at a mean temperature of 78°F.

Twenty-two individuals, took twenty to twenty-three days to transform, at mean temperature varying between 69°F—86°F. The average time of twenty-five records is 21 days, while the mode is also 21 days, at mean temperature varying between 69°F—83°F, in practically all months of the year.

14. MOULTING OF NYMPHS.

When about to moult, a fine rupture appears from the vertex to the base of the metanotum. The head of the emerging nymph or adult is pushed out first, and the moulted skin previously covering the head and thorax occupies a ventral position. The emerging nymph or adult slowly crawls out, and the moulted skin is always left attached to the undersurface of leaves or on bark of shoots by the legs. The whole process of moulting from one stage to another occupies thirty minutes.

15. RECENTLY MOULTED ADULT.

In a particular case on the 13th March 1931, a freshly transformed *S. nigroclypeata* adult was closely watched, and the following observations were recorded with regard to its coloration and development:—

8-30 A.M.—The fresh adult is whitish in color; eyes reddish; wings white; abdomen elongated, with light pink streaks between eyes, at middle of pro-and mesonotum, at base and sides of metanotum, and on first abdominal segment. Wings about a quarter of the length of the body; legs and rostrum whitish.

8-45 A.M.—Wings whitish, and have grown to three-quarters of the length of body. The abdominal segments have contracted.

8-50 A.M.—Wings still whitish, but have expanded, and covered the abdomen, leaving only the sixth and seventh segments exposed.

9 A.M.—Wings as long as the abdomen, darkish white; venation of tegmena distinct; pink rings visible in between abdominal segments; eyes dark.

9-25 A.M.—Spines on eyes become visible; rostrum brown at base; femur and tibia darkish at places.

9-35 A.M.—Wings have become darkish with spots.

9-50 A.M.—The hopper has assumed its yellowish brown coloration with dark brown speckling, legs yellowish with dark brown stripes.

16. LIFE OF ADULT.

In nature the imago of *Sarima nigroclypeata,* should have a maximum life of three to three and a half months throughout the year. In captivity inside sleeves, and in insectary cages, six records of adult life have been made between January and November, with a range of 93 to 107 days.

17. FECUNDITY AND SEX RATIO.

The female hopper lays eleven to twelve eggs at a time up to a total of 124. Counts in the overies have not been made. The sex ratio based on reared colonies is 1: 1.

18. DURATION OF LIFE-CYCLE.

The following table summarizes the time variation in the stages of the life-cycle:—

Stage.	Shortest period (days).	Longest period (da .	Average period (days).
Egg	17	25	21·4
First instar	15	24	19·2
Second „	14	24	19·4
Third „	16	23	19·9
Fourth „	18	23	20·7
Fifth „	19	24	21·
Total .	99	143	121·6 days

The difference between the shortest and the longest periods from oviposition to adult is 44 days. The average is 121·6 days, and the mode is the same.

19. EFFECT OF TEMPERATURE ON DEVELOPMENT.

The difference of fourty-four days between the shortest and the longest records of the life-cycle, may possibly be due to differences in temperature. The temperature records, do not support seasonal variation in the rate of development of the different broods during the year. For example in the months of December—January at mean temperatures of 68°F—71°F, the egg takes 23 days to hatch;

in the month of March at a mean temperature of 74°F, the egg took 24—25 days to hatch; while in the month of June at a mean temperature of 82°F, the egg took 23 days to hatch. From above it is inferred, that the development is independent of the mean temperature during different months of the year. Most of the transformations of the different stages, take place within 17 to 23 days at mean temperatures varying from 68°F—87°F. This uniformity of development throughout the year, is to be expected of a species adjusted to an equable climate. *Sarima nigroclypeata* is active throughout the year.

20. NUMBER OF GENERATIONS.

Allowing a fortnight for mating and maturation of the egg, it is evident that a minimum life-cycle of 99 days, combined with an average life-cycle of 121·6 days, permit a sequence of three generations in a year. As the adults live for over three months, and the egg laying also goes on a long time, the generations overlap. Under insectary conditions three broods have actually been carried through, the first in January to April, the second in May to August, and the third in September to December.

21. BIOTIC POTENTIAL.

Assuming that the egg laying capacity of this species is 124 eggs per female, the sex ratio is 1 : 1, the number of individuals produced from one egg is one, and the number of generations per year is three, then the annual biotic potential for the species starting with a single pair is

$$(2 \times 62 \times 1)^3 = 1906624 \text{ individuals.}$$

22. SEASONAL INCIDENCE AND RELATIVE ABUNDANCE FROM QUANTITATIVE AND FIELD COLLECTIONS.

The samples of the population of sandal insects, made at regular intervals by field assistants under the writers' direction, were analysed at Dehra Dun by Mr. C. Dover. The diagrams given in Plate II are prepared from his data, and are corrected modifications of those issued on pp. 16, 17, of the 5th progress report of the Sandal Spike Working Committee, (3; pp. 16—17). Of the total of 2,048 specimens, obtained in one year's quantitative collections from the sample plots at Fraserpet, Jawalagiri, Aiyur, and Kottur;

the Aiyur plots yielded 53 per cent., Jawalagiri 40 per cent., Fraserpet 4 per cent., and Kottur 2 per cent., Pl. II, fig. 2. At Fraserpet this species is relatively most abundant in plot No. 5, which is heavily spiked, and least abundant in plot No. 6, which is healthy. At Jawalagiri *S. nigroclypeata* is more or less uniformly present in all the plots. Its relative high occurrence in spiked plots 9 and 14, in which the ground was dug up and manured, and the spiked trees were removed every month, is worthy of note. The low figure for plot 10, is due to the fact, that the plot was completely burnt by fire in April 1931, and quantitative collections were not made in the plot, for a subsequent period of about five months. At Aiyur this species is relatively more abundant in the healthy plots 16, 17, and 18, pl. II, fig. 1. Its abundance in spike plot 20, is more or less the same as in spiked plot No. 9 of Jawalagiri; and the species is fairly abundant in the heavily spiked plot 19. At Kottur, though it occurs in all the plots, this species may be considered as relatively rare. The graph for seasonal incidence, pl. II, fig. 3, shows that there is a gradual increase in abundance from April to August, followed by a decrease to November; the population increases again, but less abundantly in the cold months December and January.

During the period March 1930 to March 1931, a separate collection of 1202 *S. nigroclypeata* was made on sandal from numerous localities by sweep netting at regular intervals. Here the monthly totals do not indicate any marked seasonal variations, but adults and nymphs occur each month.

These observations on the free population confirm those made on caged individuals, namely that the species is active throughout the year.

23. NIGHT COLLECTIONS.

During the period October to December 1931, collections on sandal were made by field assistants in Denkanikota range, for one hour on alternate days at night, and out of a total of 250 specimens of Hemiptera obtained, *S. nigroclypeata* represented 11 per cent.

24. ENEMIES.

Sarima nigroclypeata in its nymphal and adult stages, does not suffer from the attacks of parasites and predators. Parasitism by a chalcid (?), was noted on one occasion in December 1930. No predators have been observed.

MORPHOLOGY.

(*Description of the various stages Pl. 1; Figs. 1 to 15.*)

25. EGG. (Pl. 1; Fig. 1.)

Oval, depressed, rounded at both ends, with a short pedicel at the cephalic end, which is slightly narrower than the posterior end. Chorion not sculptured, but shows at certain angles fine broadly spaced furrows, which are straight on top but curved at sides. Length including pedicel 0·95—1·25 mm; breadth 0·35—0·50 mm.

First Stage Nymph.

On emergence from the egg, the nymph is of pink to crimson in color. It acquires its general pinkish-brown coloration with a whitish bloom within 48—72 hours. Eyes dark red; face, vertex, middle of thorax, and abdomen pale throughout; pro and mesonotum pale or whitish at the lateral margins; metanotum pinkish brown; abdomen basally pink, apically pinkish brown; apex of tibia, tarsus, and rostrum whitish or pale; antenna and base of rostrum pale brown to brown; legs banded brown. Sensory pits whitish or pale some surrounded by brown rim. Anal brushes white with black bands, and begin to grow within 12—24 hours of hatching. The proportion of anal brushes to the length of the body of the nymph is about 1 : 1.

Head narrower than pronotum. Vertex slightly produced in front of the eyes, rounded at the anterior margin, angularly emarginate at the posterior margin. Face a little longer than broad convex, apical and lateral margins faintly ridged with a fine central longitudinal carination, with a series of sensory pits on apical and lateral margins. Thoracic segments distinct, mesonotum longer than pronotum, metanotum about twice as long as pronotum; anterior margin of pronotum angularly produced in between the eyes, posterior margin sinuate, with a series of 8 sensory pits placed obliquely on either side of the mid dorsal carination, which runs from base of metanotum to apex of pronotum. Mesonotum with 4 sensory pits on either side of the mid dorsal ridge. Metanotum with 2 sensory pits placed obliquely on either side of the mid dorsal carination. Legs of moderate length, third pair longest. Posterior trochanter only dentate, apex of tibia and first tarsal joint of the third leg with small brown spines, 4 on each. Anterior and intermediate legs without spines. Tarsal joints two, first joint shorter than the second in the anterior and intermediate legs but longer than the second in the posterior leg. Abdomen with seven discernible segments, first segment small, third, fourth, fifth and sixth segments, each with 2 sensory pits, on either side near lateral margins. Anal brushes come out from two small kidney-shaped white pads, situated at the sides of apparently the last abdominal segment. Each brush is composed of a bundle of white wax bristles, which increases in length with the age of the nymph, and becomes banded with black. Length 1 mm.—1·25 mm; length of anal brushes 1 mm.

Second Stage Nymph.

A freshly moulted second stage nymph is pinkish white in color, with pink spots on both dorsal margins of abdominal segments and also at base of first abdominal segment. Three pink spots situated in a triangle are seen at the apex of pronotum. The eyes are at first pink, and then turn deep red. Legs and proboscis are whitish. In mature specimens the general coloration is pinkish-brown. Vertex and face pale yellow; antenna, clypeus, and base of rostrum brown. Thorax and abdomen pale at middle; pro and mesonotum pale at lateral margins, metanotum brown with pale spots at posterior margin. Legs pale banded brown, abdomen pinkish white at base, pinkish brown at apex. The anal brushes begin to grow after 24 hours of moulting, and the proportion of the length of the brushes to the body of the nymph is about 1 : 1.

Head including eyes not as broad as pronotum. Vertex subpentangular, about twice as broad as long, slightly produced in front of the eyes, with a fine central carinate line. Face as in the first stage nymph, slightly ampliated, sinuate before clypeus. Clypeus short, robust. Pronotum shorter than mesonotum, transversely smaller than the following two segments, sinuate at base, anterior margin angularly produced in between the eyes, a faint median carination present, with 9 sensory pits placed obliquely on either side of the median ridge. Mesonotum faintly tricarinate at middle, with 4 sensory pits on either side of the carinations. Metanotum with a faint median carination, sinuate anteriorly, posterior margin angularly produced at sides about twice as long as pronotum, with 2 sensory pits placed obliquely on either side. Apex of tibia and first tarsal joint of the third leg with small brown spines, 5 on each.

The anterior pairs of legs without spines. Legs and tarsal joints as in the first stage nymph. Abdomen broad at base, tapering posteriorly, first abdominal segment transversely smaller than the second segment. Third, fourth, fifth and sixth abdominal segments, each with 2 sensory pits, on either side near lateral margins. The abdomen is mildly ridged mid-dorsally in the male which is smaller than the female. Anal pads larger than those of first stage nymph. Anal brushes as in the first stage nymph but with more numerous bristles. Length 1·5 mm—1·75 mm; length of anal brushes 1·75 mm; greatest breadth over thorax on the metanotum 0·85 mm; breadth between the eyes 0·65 mm.

Third Stage Nymph. (Pl. 1; Fig. 2.)

General colour pinkish brown. Vertex, face, clypeus at base, middle of thorax and abdomen dorsally, apex of rostrum pale or pale yellow. Femora, tibiæ and tarsii darkish, banded. Compound eyes dark red, with a thin white film. Antenna, clypeus, and base of rostrum brown. Pro and mesonotum pale at lateral margins, metanotum with pale spots. Abdomen whitish pink brown, basally whitish pink, apically pinkish brown above, with pale brown patches on the third, fourth and fifth segments beneath. The anal brushes and the bands on them are most conspicuous in this stage. The ratio of the length of the anal brushes to the length of the body of the nymph is about 1·5: 1.

Head, vertex, face, clypeus, pro-meso and metanotum, as in second stage nymph. The faint mid dorsal carination on the pronotum is continued over the meso and metanotum. The angularly produced anterior margin of the pronotum is slightly raised and ampliated. Pronotum with 12, mesonotum with 8, and metanotum with 4 sensory pits placed on either side of the medio-dorso-longitudinal carination. Legs and tarsal joints as in the second stage nymph. Apex of tibia and first tarsal joint of the posterior leg with 5 brown spines on each. Abdominal segments as in the second stage nymph. Second abdominal segment with 1 sensory pit, third, fourth, fifth and sixth abdominal segment each with 3 sensory pits on either side near anterio-lateral margins. Anal pads larger than those of the second stage nymph. Anal brushes as in second stage nymph but with more numerous bristles. Length 1·80 mm.—2·25 mm; length of anal brushes 2·75 mm.—3·5 mm; breadth over thorax on the metanotum 1·25 mm; breadth between eyes ·9 mm.

Fourth Stage Nymph.

Similar in coloration to third stage nymph but more dark brown. Vertex, pro-meso and metathorax, brown, mottled. Abdomen light brown, with transverse pink bands in between segments, more brown apically. First abdominal segment castaneous at the extreme lateral margins. Sixth abdominal segment with a castaneous spot at middle of the posterior margin. Face brown, speckled; clypeus at base pale. Femur, tibia, and tarsus pale, banded brown. Eyes dark red. Antenna, clypeus, and base of rostrum dark brown. The proportion of the length of the anal brushes to the length of the body of the nymph is above 1: 1.

Head, vertex, face, and clypeus as in the third stage nymph. Pronotum smaller than mesonotum or metanotum. The medio-dorso-longitudinal carination runs from vertex to base of metanotum. The angularly produced anterior margin of the pronotum slightly elevated and ampliated. Pronotum with 15 sensory pits, placed obliquely on either side of the median ridge. Mesonotum tricarinate with 8 sensory pits, 5 near middle and 3 on tegminal region, on either side. Metanotum with 6 sensory pits in two groups of 3 each, on either side of the median carination, one group near middle and the second on tegminal region. Tegmina on meso- and metanotum present, but small and inconspicuous. Legs and tarsal joints as in the third stage nymph. Apex of tibia, and first tarsal joint of the posterior leg, with 6 black spines on each. Abdominal segments as in the third stage nymph. Second abdominal segment with 2 sensory pits, third, and fourth abdominal segments each with 4, and fifth, and sixth segments each with 3 sensory pits on either side near anterio-lateral margins. Abdomen mildly ridged mid dorsally in the male which is smaller than the female. Anal brush pads, larger than those of the third stage nymph. Anal brushes as in third stage nymph but with more numerous bristles. Length 2 mm.—2·5 mm; length of anal brushes 2 mm.—2·25 mm; breadth over thorax on the metanotum 1·5 mm; breadth between eyes 1 mm.

Fifth Stage Nymph.

General coloration, pale pinkish dark brown or black. Eyes dark red with a whitish film. Vertex, face, pro—and mesonotum, and first four abdominal segments over a greater area, pale with dark brown or black mottling. Pronotum with brown spots;

mesonotum pale at middle, and at anterio-lateral area; metanotum dark brown or black, with large pale spots. Two oblique pale lines on the metanotum, on either side of the median ridge, reach as far as the mesonotal carinations. Apices of tegmina, apical three abdominal segments, clypeus except at base, base of rostrum, and antenna dark brown or black. Abdomen in between segments pinkish above, with a pair of large dark brown or black patches on the third, fourth and fifth segments, beneath. Legs banded dark brown or black. Tegmen dark brown or black, conspicuous with pale, and brown or black striations. The wax bristles composing the anal brushes are most numerous in this instar, and the proportion of the length of the anal brushes to the length of the body of the nymph is about 1·5 : 1.

Head including eyes narrower than pronotum. Vertex subpentangular, its base angularly emarginate, with a fine carinate line, twice as broad as long, slightly produced in front of the eyes. Face slightly ampliated, sensory pits at apex and sides, sinuate before clypeus, with one central and two curved marginal carinations which meet at apex. Clypeus short, robust, shining. Antenna dark brown, second joint longer and stouter than the first, globose, with a number of fine sensory pits and hairs. Basal aristal knob minute globose. Pronotum transversely smaller than the following two segments, sinuate at base, anterior margin slightly ampliated, and angularly produced in between the eyes, with 18 sensory pits placed obliquely on either side of the median carination. Mesonotum tricarinate angularly produced posteriorly at sides, with 11 sensory pits on either side, 5 near middle in one group and 6 distributed over the tegminal region. Metonotum sinuate anteriorly, angularly produced at sides posteriorly, with 3 sensory pits placed in one group near middle on either side of the median ridge. Tegmina conspicuous. Posterior legs longest with the trochanters dentate. Apex of tibia, first and second tarsal joints with small black spines, the number of spines being 7-8 at apex of tibia, 7-10 at apex of first tarsal joint and 1-3 on the second tarsal joint. Tarsal joints two in the anterior and intermediate legs, but three in the posterior leg. Abdominal segments as in the fourth stage nymph. Second segment with 3 sensory pits; third, fourth, and fifth segments each with 4 sensory pits, and the sixth segment with 3 sensory pits, on either side near apical margins. Abdomen mildly ridged in the male which is smaller than the female. Anal brush pads, larger than those of the fourth stage nymph. Anal brushes as in the fourth stage nymph but with more numerous bristles. External genital organs dark brown or black. Length 2·75 mm.—4·5 mm; length of anal brushes 5 mm.—6·75 mm; breadth over thorax on the metanotum 2·5 mm; breadth between eyes 1·5 mm.

26. Adult.* (Pl. 1; Fig. 3.)

'Vertex twice as broad as long, surface deepened in the middle, with white grainy middle line. Face somewhat less long than the maximum breadth, tapering between eyes on sides, surfaces rounded to clypeus flat, sprinkled with deep brown, with three obvious carinations, bounded with each other in the middle of upper margin of face, the lateral carinations are close against the sides of the face, the middle carination runs through the length of face upto clypeus. Clypeus with the exception of a small yellowish-white base; black, glossy, and not keeled. Pronotum and mesonotum brown or black spotted, the later with three obvious longitudinal carinations. Tegmen longish, narrower at the apical end, brownish yellow, sometimes irregularly black spotted. At the apical end both the radial veins run closely towards each other. From the root branches a shorter nerve joins in a loop with the outer radial nerve. Wing smoky brown. Underside pale yellow, sometimes with dark longitudinal markings and on either side are present a row of black dots. Legs pale yellow, fumur with brown longitudinal stripes, on the tips of tibia are seen small dark dots ♂ ♀ length 5 mm.'

The male is smaller than the female. In twelve specimens of males and females selected out of a large number of specimens, the length from apex of vertex to the apex of tegmina, varied from 4 mm. to 4·5 mm., the average being 4·2 mm. in the case of the male; and from 4·75 mm. to 5·5 mm., with an average of 5 mm., in the case of female.

27. DEVELOPMENT OF ANTENNAE AND PRESENCE OF SENSORY PITS AND HAIRS ON THE SECOND ANTENNAL JOINT.

In the first instar the second joint of the antenna is robust, globose, studded with minute projections, being longer and broader than the first joint; which is small, plain and annular. At the apex of the second joint is seen a knob, the aristal knob, with two

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(* Footnote.—Description translated from Monographie der Isiden by Melichar.)

fine hairs, and minute tubercles, lateral to which arises the seta, Pl. 1; Fig. 5. In the second instar, both the second joint, and the antennal knob, are spinulate or are studded with black minute projections, with few olfactory spots on the second joint. At one side of the antennal knob, are seen two long hairs, with few small tubercles probably sensory in function; and on the opposite side is seen a small pointed tubercle outside which the antennal seta arises. In the third instar, the second joint with few small, olfactory pits, is also longer and broader than the first. Both the second joint, and the antennal knob, are studded with black minute projections or blunt spines, with small spines and hairs at apex. The large hairs on the aristal knob seen in the second instar are also present and the seta arises from the knob laterally. In the fourth instar, the second joint is with small olfactory pits, minute spines, and hairs, all over, more so at apex. The antennal knob is small, globular, studded with minute spines, and the seta arises laterally. In the fifth instar, the second joint is spinulate with a number of stout, pointed, transparent setae. A series of large sensory foveæ are seen on the second joint each with 5-7 thin triangular pointed projections at the outer edge. Antennal knob with sensory pits, fine hairs, and minute tubercles, at apex. In the adult stage, Pl. 1; Fig. 6, the second joint is spinulate also, with a number of stout, transparent, pointed setæ, amongst which are present a number of large olfactory pits; each with 7-10 thin triangular pointed projections at the outer edge. Antennal knob small, smaller than that of the nymphs, globose without hairs, but with sensory pits and minute tubercles. The seta arises laterally.

28. DEVELOPMENT OF LEG AND PRESENCE OF TACTILE HAIRS.

TROCHANTER: The trochanter of the posterior leg in all the nymphal stages, is dentate at the inner margin, Pl. 1; Fig. 9; which is not seen in the anterior and intermediate legs, nor in any of the legs of the adult.

FEMUR: In the first and second stage nymphs, the femur of the anterior and intermediate leg, is studded with small setæ and hairs. In the third and fourth stage nymphs, the femur of the first and second leg, is studded with small whitish pointed spines, besides setæ and hairs. In the fifth stage nymph, small pointed brownish spines are present in double row on the fumur of the first and second leg, besides the setæ and hairs. The fumur of the posterior leg, is studded with small fine spiculæ in the first four instars, and with small setæ in the fifth instar. In the adult stage the fumur of the anterior, intermediate and posterior leg, is similar to that of the fifth stage nymph.

TIBIA: The tibia of the first and second leg in all the nymphal instars, and in the adult is destitute of spines Pl. 1; Fig. 11. The tibia of the anterior and intermediate leg, Pl. 1; Fig. 12, is studded with small fine hairs in the first instar, with fine spiculæ in the second instar, and with fine setæ and hairs in the third, fourth and fifth instars and also in the adult. The tibia of the posterior leg in the first instar has besides fine hairs, 4 castaneous-tipped spines at apex Pl. 1; Fig. 7. In the second instar, besides fine spiculæ, there are one spine at middle, and 5 spines at apex of the third tibia. In the third instar, besides setæ and hairs, are present one brown-tipped spine near base, one at middle, and five at apex of the third tibia. In the fourth instar are present one brown-tipped spine near base, one at middle, 6 at apex, and one spine in between the middle spine and the apical spines besides setæ and hairs. In the fifth instar besides setæ and hairs, are present 7 or 8 black-tipped spines at apex in addition to the three spines seen on the tibia of the fourth instar, Pl. 1, Fig. 8; and 8 black-tipped spines at apex with only two other spines, the basal spine being absent, in the adult.

TARSUS: The number of tarsal joints in the anterior, intermediate, and posterior legs, of the first four instars, is two. In the fifth instar, the number of tarsal joints in the first, second and third legs, is two, two, and three respectively. In the fourth and fifth instars, the first tarsal joint in the posterior leg becomes prominent, and remains so in the adult stage, in which the number of tarsal joints in all the legs becomes three. In all the nymphal instars, the first tarsal joint is much smaller than the second in the anterior and intermediate legs and longer than the second in the posterior legs. In the fifth instar, the first and the third tarsal joints are subequal, but the first joint is stouter and more prominent than the third, which is slender and bears no spines. In the adult, the third tarsal joint is longest, being longer than the first and second put together in the first and second legs; but in the third leg the first tarsal joint is longest.

The tarsal joints of the first and second legs in all the nymphal instars and in the adult, are destitute of spines.

In the nymph of the first instar, 4 brown-tipped spines are present at the apex of the first tarsal joint in the posterior leg, the second joint is without spines. Few small tactile hairs are present on the tarsal joints of all legs. In the second instar fine tactile hairs are mostly present ventrally in all legs, more so on the third leg. At the apex of the first tarsal joint of the third leg, are seen 5 brown-tipped spines ventrally. Spines are absent on the second tarsal joint. In the third instar 5 brown-tipped spines occur at the apex of the first tarsal joint, the second tarsal joint is devoid of spines. Tactile hairs are present on both the tarsal joints of the first and second legs ventrally, but are more abundant on the tarsal joints of the third leg. In the fourth instar, tactile hairs are present on the tarsal joints of all legs as in the third instar nymph. There are 6 brown-tipped spines at the apex of the first tarsal joint but none on the second tarsal joint. In the fifth instar tactile hairs are distributed all over the first and second tarsal joints of the anterior and intermediate legs ventrally. In the posterior leg, the second tarsal joint is smallest, the third tarsal joint is less hairy than either the first or the second, on which hairs are concentrated at the apex. There are present 7-10 black-tipped spines at the apex of the first tarsal joint, and 1-3 spines on the second tarsal joint, but none on the third joint. In the adult, hairs are distributed all over the three tarsal joint of all legs, but they are more abundant ventrally. The hairs are small, pointed, and arise out of circular translucent spots. The first tarsal joint has 15 black-tipped spines at apex, the second tarsal joint only 2, while there are no spines on the third tarsal joint.

CLAWS: The tarsal joints in all nymphal stages, and in the adult, end in a pair of light to dark brown, curved and pointed claws; in between which is a bunch of small tenent hairs bent at tips, Pl. 1; Fig. 10.

29. ANAL PADS AND BRUSHES.

Nymphs of all instars have a pair of small, thick, kidney shaped, white pads, one on either side of the anal plate, from which the anal brushes develope. Each brush consists of two bundles of white, rather stiff, wax bristles; placed very close to one another. These bristles increase in number with each moult, and become banded with black at different places throughout their lengths.

The base of each bristle, is in the form of a circle or ring with an internal transparent area, bordering which are small transparent spots, the bases presumably of minute setæ; which are not discernible under low power. In between these circles are present slightly larger transparent spots, which probably are the bases of still larger setæ. When seen under high power, these rings appear in the form of shallow cups or pits with the edges projected, round each of which are seen fifteen to seventeen very minute setæ, in the case of the nymph of the fifth instar

The anal brushes and pads drop off with the exuvium, and fresh bristles arise in their places as the nymphs continue to feed and grow, after every moult. If the bristles forming the anal brushes, are cut off or removed intentionally in the middle of the nymphal stage, they again grow and the nymph does not appear to be in any way the worse for their removal.

The pads become larger in size with each moult. In the nymph of the first instar the number of anal bristles on each pad is seven, Pl. 1; Fig. 13, in the second instar nine, in the third twelve, in the fourth sixteen, and in the fifth instar over sixty, Pl. 1; Fig. 14. In the adult stage the anal pads entirely disappear, and no brushes are seen either in the male or in the female.

30. GROWTH OF ANAL BRUSHES AND THEIR FUNCTION.

The wax bristles composing the anal brushes are most numerous in the nymph of the fifth instar, and the bluish-black bands on them are most conspicuous in the third instar. In order to determine the time and rate of development of the anal brushes, a nymph of the third instar was kept under observation from 10 A.M. on the 27th February 1931. The brushes were not visible on the first day. The anal brushes when they first appear, are glistening milky white in color. On the second day only a small white stump was seen to come out. On the third day the white brushes were with two glistening bluish black bands, and had attained only half the length of the body of the nymph. On the fifth day the brushes had grown to three-quarters the length of the body of the nymph, and had three bands. On the eleventh day the brushes were one and a quarter times the length of the body of the nymph, and showed four bands. On the fourteenth day the nymph was seen to have developed five shining bluish-black bands on the brushes, which were a little less than one and a half times the length of the body of the nymph. On the sixteenth day, the brushes were found to have grown a little over one and a half times the length of the body of the nymph, and had developed seven bands. The relative position of the bands on the brushes was as follows:—The distances between the first and third, third and fifth, and fifth and seventh band were about equal. The distances from the apex of the abdomen to the first band, and from the first to the second band were equal. The distances between the second to the third, the third to the fourth, and the fourth to the sixth were subequal. The distance between the sixth and the seventh band was longest. The distance between the fifth and the sixth band was about equal to that between the first and second. The seventh band was longest and beyond the seventh band the brushes extended for a distance equal to that between the fifth and sixth band. At 2 P.M. on the sixteenth day the anal bristles were seen reduced to mere stumps. The fragile anal brushes grow with the nymphs and after a certain stage dwindle prior to moulting. With age the brushes loose their stiffness and luster.

The exact function of the anal brushes is not understood, nor is the development of the bluish black bands on them. The object of spreading the brushes fanwise, and of carrying them over the back, may be to scare and drive away predatory and parasitic insects.

31. MALE GENITALIA. (Pl. 1; Fig. 15.)

Aedegus short, phallosoma four lobed in the region of the mouth, the two dorso lateral lobes hard, pointed, each carrying small, thin, legume-shaped, appendages, pointed and curved at tip, and serrated at the outer edge. Conjunctiva appendages well developed, flattened, spinulate at the distal ends, with two pointed secondary processes. Vesica wide, and blunt at apex. Parameres broad, studded with thin spines, slightly produced at the posterio-dorsal region with a thin process before the posterio-dorsal corner, where it is slightly twisted.

32. EYES. (Pl. 1; Fig. 4.)

The surface of the compound eyes in all the nymphal stages is glabrous, but in the adult stage the eyes are studded with very minute spear shaped spines all over, except for a small area near the antennæ.

33. DISTINCTION BETWEEN NYMPHAL INSTARS.

The differences between the nymphal instars, are but for appearance and size minute, and the nymphs of the different instars cannot be separated easily without making a special study of their characteristics. The distinguishing characters lie in the number of sensory pits on pro meso and metanotum, and also on the second to sixth abdominal segments; and in the development of spines on tibia and apices of first and second tarsal joints of the posterior leg. A reference to the following table will indicate the different stage nymphs accurately.

Part of body.	NYMPHS.					Adult.
	1st Stage.	2nd Stage.	3rd Stage.	4th Stage.	5th Stage.	
Number of sensory pits on Pronotum.	8	9	12	15	18	0
Number of sensory pits on Mesonotum.	4	4	8	8	11	0
Number of sensory pits on Metanotum.	2	2	4	6	3	0
Number of sensory pits on 1st abdominal segment.	0	0	0	0	0	0
Number of sensory pits on 2nd abdominal segment.	0	0	1	2	3	0
Number of sensory pits on 3rd abdominal segment.	2	2	3	4	4	0
Number of sensory pits on 4th abdominal segment.	2	2	3	4	4	0
Number of sensory pits on 5th abdominal segment.	2	2	3	3	4	0
Number of sensory pits on 6th abdominal segment.	2	2	3	3	3	0
Number of tarsal joints to anterior and intermediate legs.	2	2	2	2	2	3
Number of tarsal joints to posterior legs.	2	2	2	2	3	3
Number of spines on and at apex of tibia of posterior leg.	0+4	1+5	2+5	3+6	3+7 or 8	2+8
Number of spines at apex of first tarsal joint of posterior leg.	4	5	5	6	7 to 10	15
Number of spines at apex of second tarsal joint of posterior leg.	0	0	0	0	1 to 3	2

34. SUMMARY.

Sarima nigroclypeata is one of the commonest hoppers on sandal in South India, and feeds on seven different plant species besides sandal. The nymphs of the first and second instars suck sap from the new leaf flush and sprouting leaf buds; while the nymphs of the third, fourth and fifth instars, as well as the adults suck sap from shoots. As a result of abnormal drain of sap due to the feeding of a large number of nymphs and adults on the sandal tree, its vitality is reduced and growth interfered with. Under laboratory conditions, feeding causes temporary shortening and clustering of leaves on shoots. As a result of mass feeding, sandal shoots and young plants die back within a short time. *S. nigroclypeata* is considered to be one of the species responsible for causing stagheadedness generally prevalent in sandal forests. The adult life is over three months, and the female has a long oviposition period. Eggs are laid on the surface of the bark of shoots. There are five nymphal stages and the average time taken to complete development from egg to adult is 121 days. There are three generations in a year and the generations overlap. The species seem to be almost entirely free of parasites and predaceous enemies. One hundred and fifty records, of the times of development of the different stages in the life history, during different months of the year have been made. Most of the transformations of the different stages take place within 17-23 days at mean temperatures varying from 68°F—87°F. The studies were mostly conducted at Denkanikota, North Salem; where there is practically no variation in the rate of development in the different seasons. This species is active throughout the year in the sandal forests of Madras, Coorg and Mysore. All the instars are described, and a table is given for the identification of nymphs. Observations on the development and morphology of antennæ, legs, anal brushes, male genitalia, and eyes have also been made.

The data recorded in this paper, suggest that *S. nigroclypeata* is a species, capable of carrying the virus of spike disease of sandal. Experiments have therefore been undertaken, with the object of transmitting the disease by means of this insect, and the results will be published when they are concluded.

LITERATURE CONSULTED.

(1) Chatterjee, N. C. (1931, 1932). *Investigations on the Spike disease of Sandal.* Indian Institute of Science, Bangalore, *Pts. I, II, IV, V.* (V. Subrahmanyan, Editor.)

(2) Distant, W. L. (1906, 1916). *Fauna of British India, Rhynchota; Vol. III, VI;* Taylor and Francis, London.

(3) Dover, C. (1932). *Investigations on the Spike disease of sandal.* Indian Institute of Science, Bangalore; *Pt. V; pp. 16-17.*

(4) Folsom, J. W. (1923). *Entomology with special reference to its ecological aspects.* John Murray, London.

(5) Imms, A. D. (1925). *A general text book of Entomology.* Methuen & Co., Ltd., London.

(6) Melichar, L. (1903). *Homopterous Fauna of Ceylon.* Felix L. Danes, Berlin.

(7) Melicher, L. (1906). *Monographie der Issiden; Homoptera.* Alfred Hebber, Vienna.

(8) Metcalf, Z. P. (1913). *Wing venation of Fulgoridae.* Ann. Entom. Soc. America; *Vol. VI, pp. 341-352.*

(9) Misra, C. S. (1916). *Indian sugar cane Leaf-hopper, Pyrilla aberrans, Kirby.* Mem. Dept. Agric. India; *Vol. V; No. 2, pp. 73-133.*

(10) Muir, F. (1922). *On the classification of Fulgoridae, Homoptera;* Proc. Hawaii. Entom. Soc. *Vol. V; pp. 205-247.*

(11) Pruthi, H. S. (1925). *The morphology of male genitalia in Rhynchota.* Trans. Entom. Soc. London; *pp. 127-256.*

(12) Osborn, H. and Drake, C. J. (1922). *Ecological studies of the Hemiptera of the Cranberry Lake region.* New York State College of Forestry; *Vol. XXII; No. 5.*

(13) Smith, K. M. (1931). *Virus diseases of plants and their relationship with insect vectors.* Biol. Reviews, *Vol. VI; pp. 302-344.*

(14) Weber, H. (1930). *Biologie der Hemipteren. Biologische Studienbucher, No. XI* Julius Springer, Berlin.

(15) Wilson, C. C. (1916). *Working plan for the Javadi and Yelagiri Hills;* Government Press, Madras.

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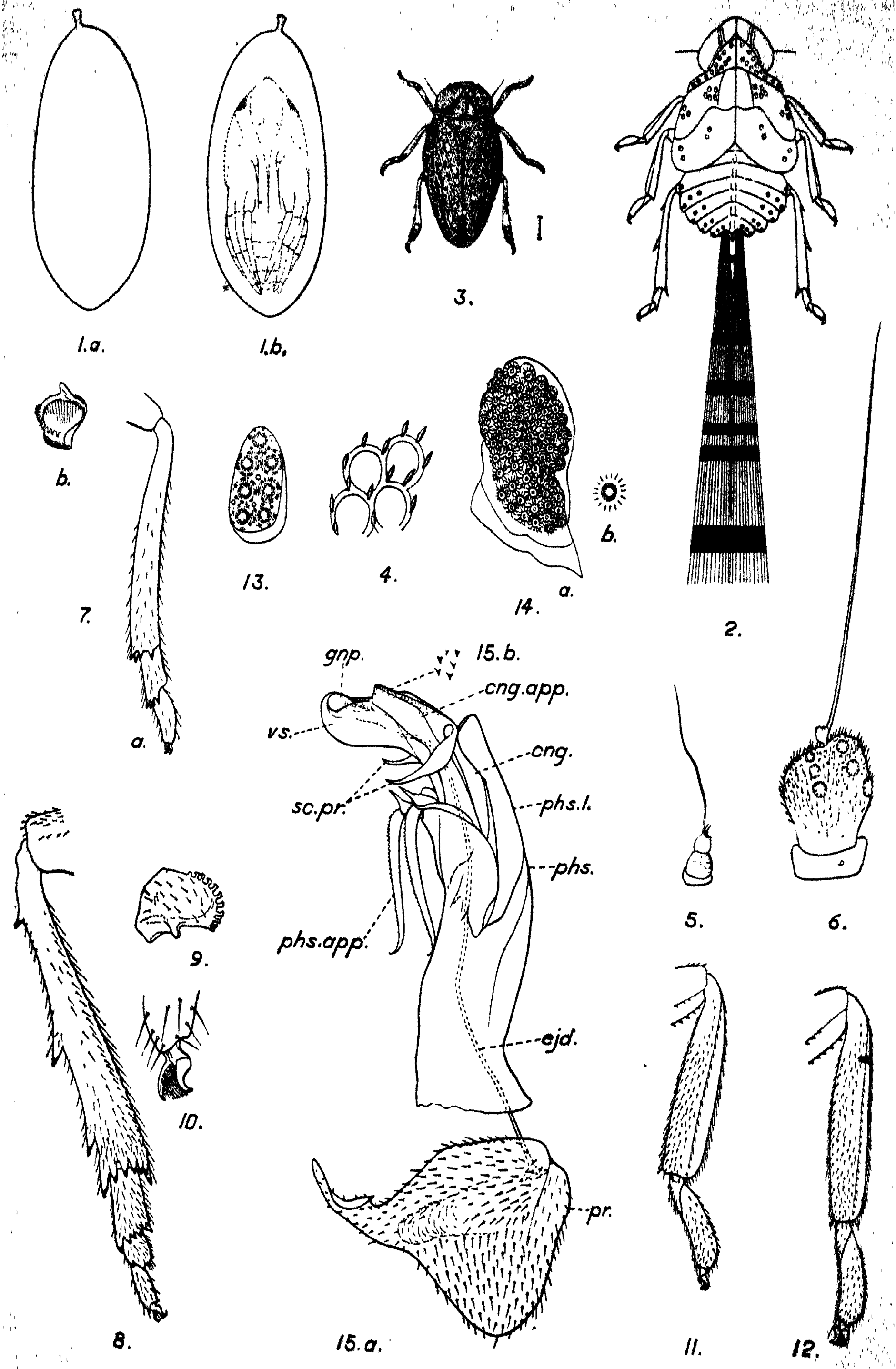
CHATTERJEE—ON THE LIFE-HISTORY AND MORPHOLOGY OF S. NIGROCLYPEATA, MEL. PLATE I.



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EXPLANATION OF PLATE I.

Sarima nigroclypeata, Mel.

Fig. 1. (*a*) Egg, (*b*) Egg about to hatch.

Fig. 2. Nymph, 3rd instar, showing sensory pits and anal brushes. Diagrammatic.

Fig. 3. Female hopper (dorsal).

Fig. 4. Portion of the eye of the adult hopper. Highly magnified.

Fig. 5. Sensory hair on antenna of nymph 1st instar. Highly magnified.

Fig. 6. Sensory hair and pits on antenna of female hopper. Highly magnified.

Fig. 7. (*a*) Posterior tibia and tarsus of nymph, 1st instar. (*b*) Posterior trochanter of nymph, 1st instar.

Fig. 8. Posterior tibia and tarsus of nymph, 5th instar.

Fig. 9. Posterior trochanter of nymph, 5th instar. Highly magnified.

Fig. 10. Tarsal claws with tenent hairs of nymph, 5th instar. Highly magnified.

Fig. 11. Anterior tibia and tarsus of nymph, 5th instar.

Fig. 12. Intermediate tibia and tarsus of nymph, 5th instar.

Fig. 13. Right anal pad of nymph, 1st instar. Highly magnified.

Fig. 14. (*a*) Right anal pad of nymph, 5th instar, (*b*) base of a single anal bristle, highly magnified.

Fig. 15. (*a*) Male genitalia. Cnj. Conjunctiva, Cnj.app. Conjunctiva appendage, ej. d. ejaculatory duct, gnp. gonopore, Phs. phallosoma, Phs. app. phallosoma appendage, Phs. I. phallosoma lobe, Pr. paramere, Sc. pr. Secondary process, Vs. vesica. (*b*) Spinules on conjuctiva appendage. Highly magnified.

EXPLANATION OF PLATE II.

Sarima nigroclypeata, Mel.

Fig. 1. Graph showing Relative abundance in Sample plots 1—28 Fraserpet, Jawalagiri, Aiyur and Kottur.

Fig. 2. Graph showing Relative abundance in Fraserpet, Jawalagiri, Aiyur and Kottur.

Fig. 3. Graph showing Seasonal incidence based on one year's totals.

SEASONAL AND LOCAL INCIDENCE OF SARIMA NIGROCLYPEATA

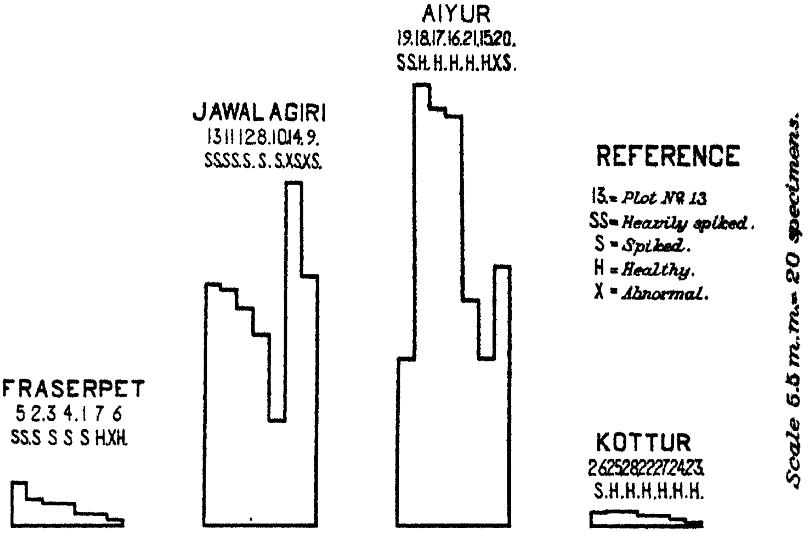

Fig 1 Relative abundance in sample plots 1-28.

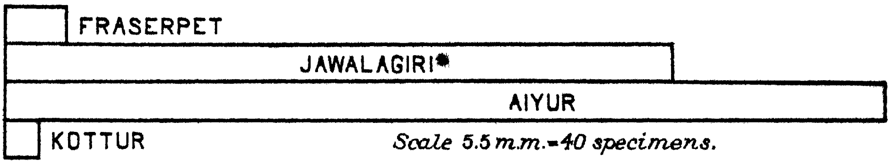

Fig 2 Relative abundance in Fraserpet, Jawalagiri, Aiyur and Kottur.

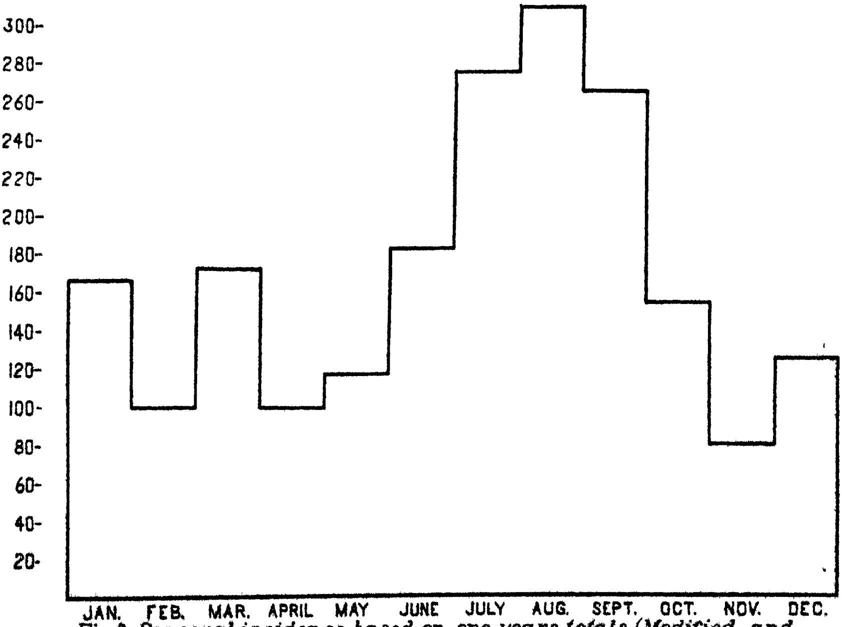

Fig. 3. Seasonal incidence based on one years totals. (Modified and corrected from Dover 1932.)

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IMMATURE STAGES OF INDIAN COLEOPTERA (13) (BOSTRYCHIDAE).

BY

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The family Bostrychidae contains numerous species of the greatest economic importance as pests of timber in the log, converted timber and bamboos; grain and certain tubers rich in starch are also attacked and finally certain species are known to attack living trees. Much valuable biological information is given by Lesne (1924) in his monograph on the Bostrychidae of tropical Africa. Beeson (1919, 1933) lists the foodplants and distribution of the Indian species.

This paper is based on larvae collected by the staff of this Institute with the exception of some valuable material provided by Dr. L. G. E. Kalshoven and Dr. F. van Emden to whom I express my thanks.

Characters of larvae of the Bostrychidae.

Boving and Craighead (1931) define the distinguishing characters of the Bostrychoidea, which they divide into five families: Ptinidae, Anobiidae, Bostrychidae, Psoidae and Lyctidae; the first two families have the head protracted and dentate mandibles; the last three, which are treated in the present paper as subfamilies of the Bostrychidae, have the head deeply retracted into the thorax and, usually, gouge-shaped mandibles. Lesne (1924) gives important information on larval structure.

The chief characters of the mature larvae of the family are as follows: Head longer than wide, deeply retracted into the thorax. Antennae usually prominent although small, with three segments and a basal connecting skin. Mandibles usually gouge-shaped distally. Labrum movable. Maxillae reinforced on the inner margin by a brownish thickening, and with or without a freely projecting maxillary stylet. Labium with prementum limited posteriorly by a transverse brown line. Submentum and prothoracic skin continuous. Legs usually well developed. Body curved, enlarged at thorax. Spiracles annular. Tenth abdominal segment in front of anus with a pair of adjacent lobes separated by a longitudinal groove. Urogomphi absent.

This paper deals with mature larvae but it is worth noting that the few first stage larvae which have been described have marked peculiarities, *e.g.*, the first stage larva of *Lyctus* has a pair of urogomphi (see page 9) and that of *Scobicia* an unpaired spine on the ninth abdominal segment (Boving, 1922, p. 53).

Division into Subfamilies.

Lesne (1920, p. 285, 1924, p. 45) has divided adult Bostrychidae into seven subfamilies : *Dysidinae* (=*Apoleoninae*), *Lyctinae*, *Dinoderinae*, *Hendecatominae*, *Chileniinae*, *Psoinae* and *Bostrychinae*. I have not seen larvae of *Hendecatominae* or *Chileniinae* but otherwise larval morphology supports Lesne's views, with a possible exception in the case of the *Apatini* which Lesne considers as a tribe of the *Bostrychinae* ; the larvae of *Apate* and *Phonapate*, according to Lesne (1924, p. 239) are characterised by rudimentary and non-salient antennae, a fact which would support any elevation of the group to subfamily rank on grounds of adult morphology.

Boving and Craighead (1931, p. 62), dealing with the larvae, consider the *Psoidae* (including *Psoa*, *Polycaon*, *Dinoderus*, *Rhizopertha*, etc.), *Bostrychidae* and *Lyctidae* to be of family rank. In the present paper these groups are treated as subfamilies and the *Dinoderinae* (*Dinoderus*, *Rhizopertha*) are separated as a subfamily.

As Boving and Craighead have shown, two groups can be separated by the structure of the mandible : in one group, consisting of *Lyctinae*, *Psoinae*, *Dinoderinae* and *Apoleoninae*, the mandible has a large fleshy cushion and a rigid grinding or pseudomolar extension which meets its fellow in a hardened concavity in the epipharynx ; in the other group, the *Bostrychinae*, there is no such rigid grinding extension ; but that this division into two groups is not so sharp as was at first supposed is shown by the mandible of *Schistoceros* which has a small but distinct fleshy cushion and a minute flexible appendage which may possibly represent a rudimentary pseudomolar part. The functional significance of the mandibular structure remains to be investigated.

Key to Subfamilies.

1. Mandible without pseudomolar process or fleshy appendage, or with rudiments only of those structures (*Schistoceros*). Epipharynx without large sclerome. Prothorax with a rod-like thickening on each side	BOSTRYCHINAE (p. 12.)
Mandible with pseudomolar process extending to a sclerome in epipharynx and with a large fleshy appendage. Prothorax without lateral rod-like thickenings	(2)
2. Last abdominal spiracle distinctly larger than the others	LYCTINAE (p. 8.)
Last abdominal spiracle small, not larger than that of thorax	(3)
3. Labial palp with one segment. Maxillary palp with two segments borne on a palpiger . . .	DINODERINAE (p. 6.)
Labial palp with two segments. Maxillary palp with three segments borne on a palpiger . .	(4)
4 Anterior abdominal terga with three transverse subdivisions. Legs unequal, the posterior pair abruptly reduced (No distinct ocelli) . .	PSOINAE (Heterarthron) (p. 4.)
Anterior abdominal terga with only two transverse subdivisions. Legs subequal. (Head with a distinct ocellus on each side)	APOLEONINAE (Apoleon) (p. 3.)

Subfamily Apoleoninae.

Characters of mature larvae.—Anterior abdominal terga with only two transverse subdivisions. Spiracles with a short finger-like projection breaking the margin; posterior spiracles not larger than the others. Legs nearly equal in size, with acute claws. Other characters as in *Psoinae* (*Heterarthron*). (Based on *Apoleon* (=*Dysides*) *edax* Gorh.).

APOLEON EDAX GORHAM.

Described from four larvae from Java provided by Dr. L. G. E. Kalshoven. The species occurs in India.

Larva (Pl. I, figs. 1-6).

Curved, enlarged at thorax; length about 16 mm; width at thorax about 4·5 mm. Setae short and dense ventrally, longer laterally. Head longer than wide (3·1 × 2·7 mm), the posterior margin subangulate. Ocelli distinct, one on each side, large, oval, situated between antenna and ventral articulation of mandible. Antenna (fig. 6) with segment-like basal connecting skin and three true segments, the third very small; segment 1 longer than wide, slightly widened distally; segment 2 gradually increasing in width from the base, rather more than three times as long as wide and about 1·4 times as long as segment 1; segment 3 one-seventh as long as second; accessory appendage minute. Labrum, clypeus and epipharynx very much as in *Heterarthron*. Mandible (fig. 4) acute apically, the cutting edge strongly oblique, with a very distinct tooth at its posterior extremity; mola-like prominence and fleshy appendage well developed. Maxilla (fig. 1) with digitiform, densely setose mala; lacinia a stout, slightly curved spine; palpiger segment-like; palp with three brown segments of which the third is the longest; second longer than wide, slightly shorter than third. Labial palps (fig. 1) with two segments, the second the longer; prementum posteriorly limited by a brown line; ligula rounded, large; mentum separated from submentum by a fine brown line on each side. Terga of mesothorax, metathorax and abdominal segments (fig. 3) divided into two prominent transverse folds of about equal size; a very attenuated strip of skin separates the two folds. Legs (fig. 2) approximately equal in size, hairy; the tibia elongate, rather slender; the claw an elongate acute spine. Spiracles (fig. 5) oval, each with a single dorsally directed finger-like air-tube projecting from margin.

Subfamily Psoinae.

Characters of mature larvae.—Labrum large, bent downwards over mandibles. Antennae prominent. Epipharynx with concave sclerome. Mandible with pseudomolar process and fleshy appendage. Maxillary stylet strong. Maxillary palp three-segmented, borne on a segment-like palpiger. Labial palps two-segmented. Prothorax without lateral rods. Anterior abdominal terga with three transverse subdivisions. Legs well developed, decreasing in size from pro- to metathorax. Spiracles oval, annular, the last abdominal pair not enlarged. (Based on *Heterarthron feanus* Lesne).

HETERARTHRON FEANUS LESNE.

Described from six larvae taken from *Mallotus philippinensis*, Dehra Dun, U. P. Beetles were reared.

Mature Larva (Pl. I, figs. 7-12).

Larva (fig. 7) large, length about 25 mm., width at thorax about 7 mm. White, with mandibles, claws, portions of mouthparts and antennae darkly pigmented. Body setae short but longer and denser on pleural region. Head subrectangular, the posterior margin gently curved; length to epistoma 3·7 mm., width 3·3 mm. Ocelli are not distinct. Antennae (fig. 9) with the segment-like basal connecting skin and the three true segments partly brown; segment 1 slightly longer than wide and strongly expanded distally; segment 2 stoutly subfusiform, wider behind the middle, twice as long as wide and a little longer than first segment; segment 3 cylindrical, small, one-fourth as long as second; appendage minute, longer than wide. Clypeus (fig. 10) rather narrowly transverse, with numerous moderately long setae on the posterior brown zone and laterally on the anterior soft zone. Labrum (fig. 10) large, about three times as long as clypeus, deflexed, forming an angle with plane of frons; wide and convex basally, narrowing towards apex; surface brownish at posterior lateral angles, with numerous setae which are short on the disc, longer laterally and denser anteriorly; a pair of short fine blackish rods is visible beyond the middle. Epipharynx (fig. 11) near the base with a concave area supported by lateral rods and with minute hairs except centrally; a posterior division of this area, just anterior to the oesophageal opening, is circular, concave and subvertical. Mandible (fig. 8) stout, the apical cutting edge roundly gouge shaped, with a small indentation separating a weak postapical angulation; mola-like projection strong, the grinding face with three carinae across the disk and with a curved pencil of setae behind it; the fleshy appendage well developed; lateral face of mandible with several setae. Maxilla with digitiform mala which is densely setose apically and on the inner margin; maxillary stylet (lacinia) a strong, slightly curved, spine; palpifer stout, segment-like; palp with basal segment stout, brownish near the base, wider than long; second segment slightly longer than wide, the third about twice as long as wide, and longer than the second (4 : 3); palpifer and two basal segments of palp with long setae on ventral surface. Labium with prementum limited posteriorly by a fine transverse brown line; palp with two segments, the first short and stout, the second twice as long as wide; ligula obtusely rounded; mentum and submentum separated by a transverse depressed line, each with numerous setae; the buccal surface with two series of long dense setae. Terga of mesothorax and metathorax each divided into two transverse folds; terga of first five abdominal segments each with three distinct transverse subdivisions and one very attenuated strip behind the first subdivision. Pleural region protuberant in a ventral direction, finely hairy. Anal cleft longitudinal. Legs (fig. 12) well developed, hairy, the coxa of anterior leg with a small, that of middle leg with a large, oval smooth yellow plate; the anterior leg slightly larger than the middle leg; the posterior leg more abruptly reduced in size and more widely separated from its fellow; tibiae curved and stout, especially in the anterior leg; claw short, truncate, with the appearance of having been abruptly amputated near the middle leaving only a basal stump. Spiracles oval, annular; the thoracic spiracle situated on prothorax near its posterior margin and with an oval shining plate just anterior to it; abdominal spiracles subequal.

The fact that the claws in all six specimens are similar seems to show that their truncate appearance is specific and not merely due to injury.

Subfamily Dinoderinae.

Larval characters of Dinoderus and Rhizopertha.—Labrum large, nearly as long as wide, bent downwards over mandibles and forming an angle with frons; with a pair of slender rods on distal half which do not reach to the apex. Epistoma concave. Clypeus narrow. Epipharynx with a distinct sclerome. Mandibles with a strong mola-like process associated with a curved brush of setae and with a large fleshy appendage. Maxilla with a well developed stylet; galea rather slender, setose; palp two-segmented with a distinct basal palpiger. Labium with one-segmented palps; prementum limited posteriorly by a fine brown transverse line; ligula not prominent. Prothorax without lateral rod-like thickenings. Anterior abdominal terga with only two transverse subdivisions. Claws well developed, slender and acute, pigmented. Spiracles annular, small, the posterior pair not enlarged.

The larvae of the two genera can be distinguished as follows:—

Rhizopertha.—Apex of mandible with three distinct teeth. Antenna with only two well defined segments. Body only slightly curved and more weakly enlarged at thorax.

Dinoderus.—Apex of mandible obliquely chisel-shaped with only one distinct tooth. Antenna with three distinct segments. Body more markedly curved and swollen at thorax.

The larva of *Stephanopachys elongatus* Pyk., as described by Saalas (1923, p. 179) has six ocelli on each side of the head. Ocelli are not distinct in *Dinoderus* and *Rhizopertha.*

RHIZOPERTHA DOMINICA F.

This cosmopolitan species is of chief importance as a grain pest, but is not limited to grain; a long series was bred from wood of *Artocarpus hirsutus* sent to Dehra Dun from S. Mangalore, Madras. An account of the biology is given by Lesne (1924, p. 52).

Mature Larva (Pl. III, figs. 32-36).

Length about 3 mm. Body only slightly curved and not very strongly enlarged at the thorax. Setae numerous and conspicuous on posterior extremity of body. Head slightly longer than wide, broadly rounded posteriorly. Antenna (fig. 36) with only two distinct segments; a basal transverse segment such as is present in *Dinoderus* apparently missing or at any rate not distinguishable from the membranous connecting skin; of the two distinct segments the first is cylindrical, distinctly longer than wide, with four long apical setae, and the second or apical segment, is about twice as long as wide, about one-half as long as preceding segment and carries on its apex three short setae and a narrowly conical 'seta.' Labrum large, more or less circular, slightly wider than long, anterior margin not very densely setose, a few setae present between middle and apex. Epipharynx (fig. 33) with strong sclerome, the concave surface apparently granulate or with minute teeth; anterior to sclerome is a patch of fine hairs which are directed towards sclerome. Mandible (fig. 34) with three distinct teeth obliquely arranged at the apex, the distal tooth stronger and more acute; grinding surface of pseudo-molar projection coarsely granulate. Maxilla (fig. 35) with several rather long and stout setae on galea; lacinia a slightly curved spine; maxillary palp with distinct transverse palpiger and two segments of which the first is stout, cylindrical and longer than wide, the second distinctly longer than the first, more than twice as long as basal width and tapering. Labial palp (fig. 35) with only one subcylindrical segment which is longer than wide. Abdominal terga with only two transverse subdivisions. Legs equal in size, the claw curved, brownish from the widened base to the acute apex; the preceding segment (tibia) with very few setae. Spiracles very small, circular, simple, those of thorax slightly larger than those of abdomen.

DINODERUS.

Characters of larvae.—Body strongly curved, swollen at thorax. Head capsule nearly as wide as long, rounded. Antenna with three district segments, the basal one transverse, and a membranous connecting skin. Epipharyngeal sclerome not coarsely granulate as in *Rhizopertha*, with numerous fine hairs directed towards the concavity. Mandible with apex obliquely chisel-shaped and with only one distinct tooth, that at the extreme apex. Legs decreasing slightly in size from prothorax to metathorax. Thoracic spiracle broadly oval, slightly larger than that of first abdominal segment and much larger than the following spiracles which are circular.

Species of this genus are of great importance as borers in bamboo: certain species bore in wood; *D. distinctus* Lesne from the Philippines is recorded by van Emden[1] from 'Radix Colombo' (*Jatrorrhiza palmata*).

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[1] Jahresbericht der Caesar & Loretz 1925, p. 208.

The correlation of *Dinoderus* larvae with their adults is complicated by the fact that several species usually occur together, at least in bamboo. Specific differences appear to be found in the antennae and palps but a detailed comparison must wait until more material is available.[1]

D. ochraceipennis Lesne (Pl. III, figs. 28-31) has been reared at Dehra Dun from a small tree (*Murraya koenigii*) and from forest climbers. Length of larva about 3 mm. Maxillary palp with apical segment tapering, distinctly longer than penultimate segment which is only slightly longer than wide. Labial palp rather short and stout, rather less than twice as long as wide and less than two-thirds as long as apical segment of maxillary palp. Posterior legs only slightly more slender than anterior pair; tibia with relatively few setae, a pair of which, on the ventral surface, is thicker; the claw is dark brown, curved.

D. minutus F. is a pest of bamboos in India and is found throughout the tropics. Dr. Kalshoven provided me with larvae of this species from Javanese bamboos. Maxillary palp with penultimate segment about equal in length to apical segment. Labial palp elongate, more than twice as long as wide. Anterior pair of legs distinctly stouter than posterior pair and with tibia more hairy than in *ochraceipennis*.

D. ocellaris Steph. is a bamboo border—Maxillary palp with apical segment distinctly longer than penultimate segment. Labial palp nearly twice as long as wide. Anterior legs distinctly stouter than posterior pair and with distinctly hairy tibia. The second antennal joint is more elongate than in the other species and is weakly constricted near the middle.

D. distinctus L., a Philippine species, is recorded from 'Radix Colombo' by Dr. F. van Emden who kindly lent me his microscopic slides of the larva.—Apical segment of maxillary palp longer than penultimate segment. Labial palp about twice as long as wide.

Lyctinae.

Characters of mature larvae.—Body small, curved, enlarged at thorax. Head capsule longer than wide, subrectangular, rounded posteriorly, epistoma concave. Antennae with a basal connecting membrane, three segments and an accessory appendage. Labrum large, bent downwards over mandibles, the anterior margin setose, the posterior lateral margins with an oblique narrow brownish thickening on each side; a transverse fold divides the surface into a smaller weakly sclerotised anterior part and a soft skinned posterior part. Epipharynx with a pair of short longitudinal rods extending to anterior thickened area of labrum, and

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[1] This also applies to *Sinoxylon* and to some species of *Lyctinae.*

with a posterior concave sclerome of variable thickness fringed with small hair like projections. Mandible (figs. 17, 22) with apical margin curved, chisel-shaped, without teeth; with a well developed soft and fleshy appendage and with a mola-like projection associated with a curved brush; this projection extends upwards and meets its fellow in the concave epipharyngeal sclerome. Maxillary palps two segmented, with a basal palpiger; mala obtuse, setose, with a slender spine-like maxillary stylet. Labium with one segmented palps. Prothorax without lateral rod-like thickenings. Anterior abdominal terga with only two transverse subdivisions.

Spiracles of eighth abdominal segment oval, very large, always larger than those of thorax; spiracles of first seven abdominal segments usually very small. Legs distinct, apparently with three segments and on the two anterior pairs at least, a slender acute spine or claw; the anterior pair distinctly stouter than the two posterior pairs.

The known first stage larvae of Lyctinae differ from mature larvae in having a straight body armed caudally with a pair of small spines or urogomphi (Boving and Craighead 1931, Pl. 102, J; Kojima 1932).

Key to larvae of Lyctinae.

1. All spiracles large, the posterior pair the largest however; those of 7th abdominal segment more than half as large as those of 8th . . .	*Trogoxylon auriculatum* Lesne.
Spiracles of first seven abdominal segments small, the seventh pair minute compared with 8th	(2)
2. Thoracic spiracle strongly transverse, more than twice as long as wide; abdominal spiracles distinctly elliptical	*Minthea rugicollis* Walk.
Thoracic and abdominal spiracles broadly elliptical or subcircular	(3)
3. Posterior abdominal spiracle larger, at least twice as large as thoracic spiracle	(4)
Posterior abdominal spiracle relatively small, not more than 1·5 times as large as thoracic spiracle.	*Lyctoxylon japonum* Reit.
4. Spiracles with small but distinct marginal lobe. Second segment of antenna longer than wide .	*Lyctus brunneus* Steph.
Spiracles without marginal lobes	(5)
5. Metathoracic leg terminating in an attenuated hyaline spine	*Lyctus fuscus* L.
Metathoracic leg without slender apical spine .	*Lyctus africanus* Lesne.

TROGOXYLON AURICULATUM LESNE.

Larvae were taken from dry stems of a creeper, *Combretum decandrum*, Dehra Dun (J. C. M. G.); beetles were reared. The species also occurs in *Shorea robusta*, and many other trees.

Larva (Pl. II, figs. 21-23).

Length about 3 mm. Body curved, enlarged in thoracic region. Setae extremely small and inconspicuous except on parts of head, legs and pleural region. Antenna (fig. 21) with second segment longer than wide; apical segment slender, distinctly longer than second, cylindrical, slightly expanded at the base; accessory appendage very slender, elongate, about half as long as apical segment. Epipharyngeal sclerome weak, scarcely pigmented, with minute skin points on each side. Maxillary mala with several apical setae some of which are wide; maxillary stylet short and fine. Mandible (fig. 22) seen in lateral view, rather elongate, the apex weakly expanded, chisel shaped; the mola-like projection not very strong. Spiracles (fig. 23) broadly elliptical to subcircular, without marginal lobes and all relatively large; the posterior pair the largest however, about 1·2 times as wide as thoracic spiracle; abdominal spiracles all large but slightly variable in size, that of first segment, oval, very nearly as wide as the subcircular thoracic spiracle. Anterior leg with numerous setae and with a long very fine acute claw; middle leg with an acute claw; posterior leg blunt with several very long setae.

This larva is very distinct, the most striking peculiarity being the relatively large spiracles of abdominal segments 1-7.

LYCTUS BRUNNEUS STEPH.

Three larvae from Java were provided by Dr. Kalshoven. The species occurs in India.

Larva (Pl. II, figs. 25-27).

Length about 5 mm. The skin with a rather dense covering of setae which are extremely short for the most part, longer on protuberant pleural region; also minutely irregular and on caudal segments, with minute points. Head about 1·0 mm. in length and 0·75 mm. in width. Antenna (fig. 26) with segment 1 transverse; segment 2 distinctly longer than wide, nearly as long as segment 3 which is equal in length to terminal segment of maxillary palp; appendage short, conical, about one-third as long as segment 3. Maxillary mala (fig. 27) with slender curved stylet near the base of which is a group of three curved setae; apical segment of palp about twice as long as width of slightly expanded basal half; basal segment slightly longer than wide. Labial palp (fig. 27) stout, slightly narrowing towards apex and almost equal to apical segment of maxillary palp. Spiracles (fig. 25) subcircular except the posterior pair which are twice as wide as those of thorax; the remaining spiracles small, those of fifth abdominal segment the smallest, about one-fifth as wide as thoracic spiracles; a small lobe projecting from the margin is very distinct on the anterior spiracles. Prothoracic leg stout with long fine claw; mesothoracic and metathoracic legs more slender, with attenuated weak claw and numerous long fine setae.

This larva is distinguished by the shape of the spiracle, elongate second segment of antenna and rather dense pubescence.

The egg and early stage larvae of this species are described by Altson (1922, 1923).

LYCTUS FUSCUS L. (LINEARIS GOEZE).

Described from two larvae from Leipzig, Germany, provided by Dr. F. van Emden. This species has not yet been recorded from India.

Larva (Pl. II, fig. 20).

Body setae numerous but very short and inconspicuous except on legs and pleural region. Antenna (fig. 20) with segment 2 weakly transverse, shorter than segment 3 which tapers towards the blunt apex; appendage moderately slender not extending to middle of third segment. Epipharyngeal sclerome strong. Maxillary stylet a strong curved spine. Thoracic spiracle nearly circular; spiracles of abdominal segments 1-7 very small, of segment 8 very large, oval, three times as wide as thoracic spiracle. Anterior leg with a longer slender spine; middle leg with a shorter spine; posterior leg also ending in a still shorter but distinct acute spine.

The early stages of this species are described and figured by Kojima (1932).

LYCTOXYLON JAPONUM REITT.

Larvae were taken, with those of *Minthea rugicollis* from bamboo, Chepauk, Madras. The two species of larvae were identified from exuviae taken from pupal chambers with the associated, nearly mature beetles.

Larva (Pl. II, figs. 13, 14).

Length about 3 mm. Antenna (fig. 14) with second segment transverse; segment three elongate; appendage weakly fusiform reaching to about the middle of the third segment. Spiracle of abdominal segment 8 about 1·5 times as wide as the broadly elliptical thoracic spiracle; spiracle of first seven abdominal segments very small, nearly circular. Metathoracic legs without an apical spine, blunt, with few long hairs.

The posterior abdominal spiracles are smaller in relation to the thoracic spiracles than in other species with the exception of *Trogoxylon auriculatum*.

MINTHEA RUGICOLLIS WALK.

Larvae were taken from bamboo, Chepauk, Madras; *Lyctoxylon japonum* was reared as well.

Larva (Pl. II, fig. 24).

Length about 3 mm. Body setae sparse except on pleural region. Antenna (fig. 24) with segment 2 not longer than wide, distinctly shorter than segment 3 and more than twice as long as the appendage. Spiracles without a marginal lobe; that of thorax narrowly oval, more than twice as long as wide; abdominal spiracles oval, the posterior spiracle nearly twice as wide as that of thorax. Legs with fine apical spines, on first two pairs; the posterior legs with a fine hyaline point.

This species is distinguished from other *Lyctinae* by the more narrowly oval spiracles.

LYCTUS AFRICANUS LESNE.

Larvae were taken from bamboo, Najibabad, U. P.

Larva (Pl. II, figs. 15-19).

Length about 3 mm. Body setae sparse and very short except on pleural region. Head as in fig. 16. Antenna (fig. 15) with segment 2 weakly transverse, the appendage about one-half as long as segment 3. Labrum and epipharynx as in figs. 16 and 18. Mandible as in fig. 17. Spiracle (fig. 19) without marginal lobe, the posterior pair widely oval, about 2·5 times as wide as thoracic pair; anterior spiracles widely oval to almost circular. Metathoracic legs terminating in a soft rather blunt point, not attenuate.

Bostrychinae.

Characters of mature larvae.—Head subrectangular, longer than wide, anteriorly more or less rugulose, pigmented near mandibular articulations. Antennae salient (except *Apatini*), the two distal segments sometimes fused. Labrum distinctly transverse, the anterior margin setose. Epipharyngeal rods strong, hook-shaped. Epipharynx without sclerome. Mandible stout, apically gouge-shaped, at most with vestiges of ' fleshy appendage '. Maxillary palp with two segments borne on a distinct palpiger; a free maxillary stylet present or not. Labial palp with two segments. Prothorax with a distinct rod-like thickening on each side. Anterior abdominal terga with three transverse folds. Spiracles oval, those of 8th abdominal segment not larger than those of thorax. Anterior legs stouter than the others; all legs with acute more or less sclerotized claw.

I have not detected ocelli in mature larvae, but a pair is present in immature larvae of *Heterobostrychus aequalis.*

Larvae of the *Apatini* are absent in this collection but from Lesne's descriptions (1924, pp. 239, 255) they are distinguished from other groups by the antennae which are reduced to vestiges of the usual three segments borne on a sclerotized and rigid basal convexity.

Key to tribes of Bostrychinae.

1. Maxillary mala with a freely projecting stylet .	(2)
Maxillary mala without a free stylet . . .	Xyloperthini.
2. Second and third segments of antenna fused . .	Sinoxylonini.
Second and third segments of antenna not fused .	Bostrychini.

Key to species of Bostrychini.

1. Mandible with a small 'fleshy appendage' and a small flexible rod-like projection . . .	*Schistoceros anobioides* Water.
Mandible without rod-like projection; 'fleshy appendage' minute or absent. . . .	(2)
2. Second segment of antenna transverse. 'Fleshy appendage' minute but distinct . . .	*Bostrychopsis parallela* Lesne.
Second segment of antenna longer than wide. 'Fleshy appendage' not evident . . .	(3)
3. Thoracic spiracle large, two-thirds width of labrum. Second segment of antenna more elongate, more than 1·5 times as long as wide . . .	(4)
Thoracic spiracle small, one-third width of labrum. Second segment of antenna stouter, less than 1·5 times as long as wide	*Heterobostrychus aequalis* Water.
4. Second segment of antenna very long, about three times as long as wide	*Heterobostrychus hamatipennis* Lesne.
Second segment of antenna moderately long, nearly twice as long as wide	*Heterobostrychus pileatus* Lesne.

Schistoceros anobioides Water.

Larvae were taken from *Holarrhena antidysenterica,* Ranchi, Bihar and Orissa.

Larva (Pl. IV, figs. 43, 44).

Length of head capsule 5·5 mm.; width 3·9 mm. Antenna with basal segment short, subglobular; the second weakly widened in apical half, elongate, about three times as long as wide. Mandible (fig. 44) with a small slender appendage extending from upper basal angle of inner face and associated with a small 'fleshy attachment'.

Maxillary mala with dense moderately long hairs; palp with basal segment cylindrical, longer than wide; apical segment distinctly wider near the base. Prementum densely hairy on each side. Ligula with two dense groups of rather long setae. Body skin with scattered fine and rather short setae. Claws well developed on all legs; anterior legs much stouter than the others but not longer: tibia of posterior pair slightly longer than those of the others; all tibiae with reddish setae which are especially dense on the anterior pair. Thoracic spiracle two-thirds as wide as labrum and twice as wide as last abdominal spiracle which is itself slightly smaller than that of the first abdominal segment.

BOSTRYCHOPSIS PARALLELA LESNE.

Described from larvae taken from *Dendrocalamus strictus*, Najibabad, U. P.

Larva (Pl. IV, figs. 50, 51).

Length about 10 mm. Head capsule 2·8 mm. × 2·3 mm. Antenna (fig. 51) short, the two basal segments transverse, the first a little longer than the second, the apical segment longer than wide; appendage very small. Mandible (fig. 50) with a very small soft protuberance near the upper basal angle of the ental face. Maxillary palp with basal segment cylindrical, longer than wide and longer than the tapering apical segment. Thoracic spiracle rather small, one-third as wide as labrum. All legs with pigmented claw.

The small soft protuberance of the mandible is still smaller than that of *Schistoceros* and also differs in not having the associated slender projection of the latter.

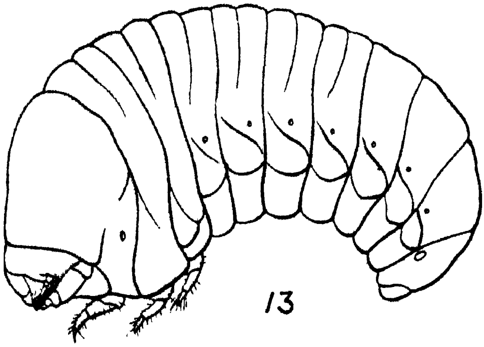
HETEROBOSTRYCHUS HAMATIPENNIS LENSE.

Larvae were extracted from *Mallotus philippinensis*, Dehra Dun, U. P.

Larva (Pl. IV, figs. 47-49).

Length about 17 mm. Body setae extremely short and inconspicuous except on legs, pleural region and on caudal segment where they are moderately long.

Head (fig. 47) rectangular, the posterior margin slightly curved; ength (to epistoma) 3·5 mm., width 2·8 mm.; anteriorly rugulose, casaneous near mandibular articulations. Without distinct ocelli. Anenna (fig. 48) with three brown segments; the first short, weakly transerse; the second widened on apical half, very long, rather more than hree times as long as width near base; third segment small, slightly nore than one-fourth as long as second; accessory appendage about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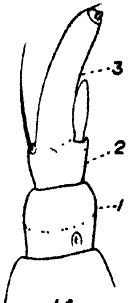

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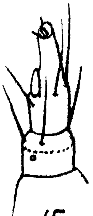
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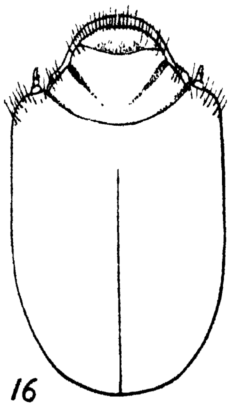
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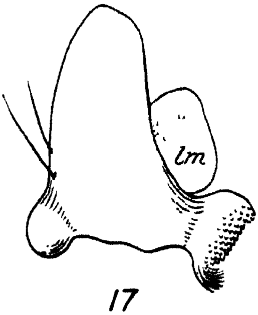

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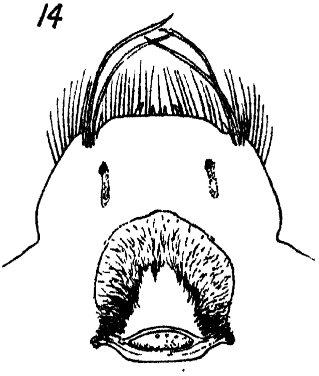
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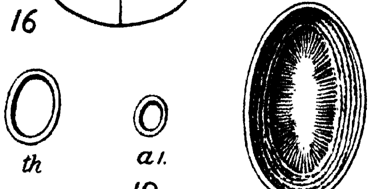

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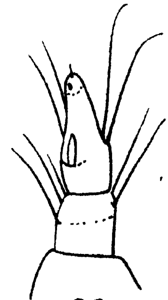
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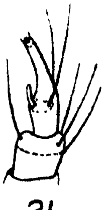
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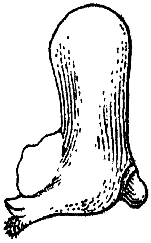
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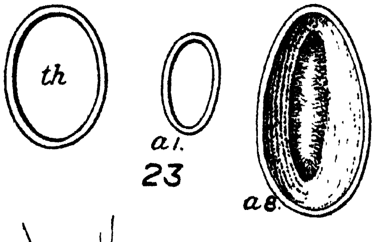

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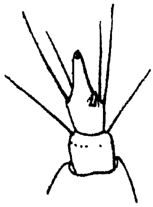
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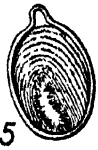
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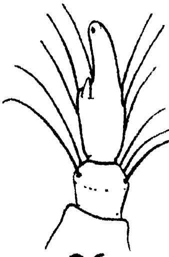
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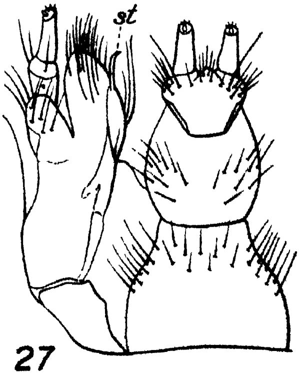

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PLATE III.

Dinoderinae and *Sinoxylonini*.

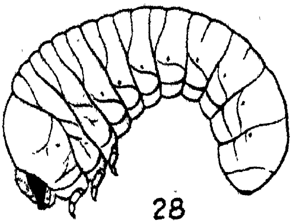
Figs. 28-31. Larva of *Dinoderus ochraceipennis* Lesne.
- 28. Lateral view.
- 29. Maxilla and labium ; *st*, stylet.
- 30. Head.
- 31. Mandible ; *lm*, ' fleshy appendage '.

Figs. 32-36. Larva of *Rhizopertha dominica* F.
- 32. Claw of anterior leg.
- 33. Epipharynx.
- 34. Mandible.
- 35. Maxilla and labium ; *st*, stylet.
- 36. Antenna.

Figs. 37-42. Larvae of *Sinoxylon* spp.
- 37. S. sudanicum Lesne, antenna.
- 38. S. atratum Lesne, antenna.
- 39. S. atratum Lesne, maxilla ; *st*, stylet.
- 40. S. oleare Lesne, antenna.
- 41. S. crassum Lesne, antenna.
- 42. S. crassum Lesne, mandible, lateral view.

PLATE III.

GARDNER—IMMATURE STAGES OF INDIAN COLEOPTERA (13)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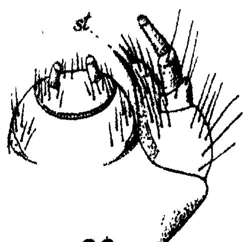

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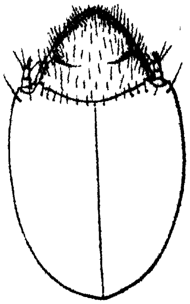
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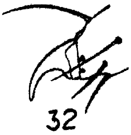
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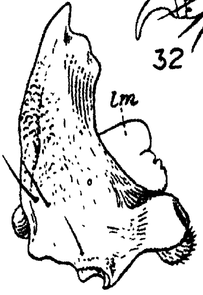

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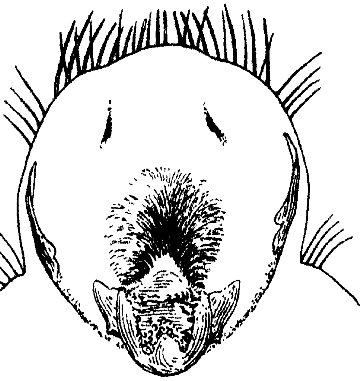
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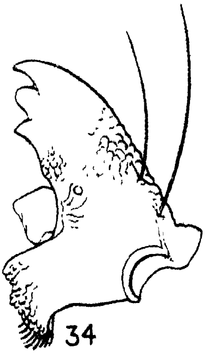
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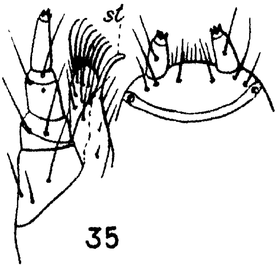

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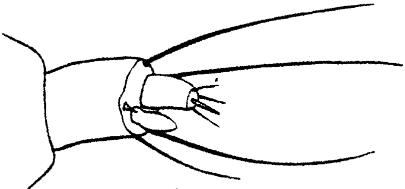
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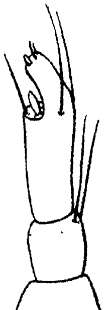
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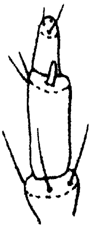
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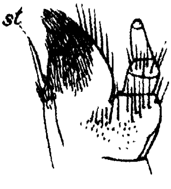

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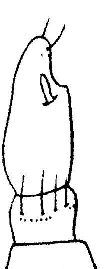
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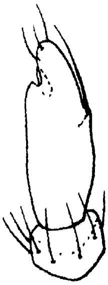
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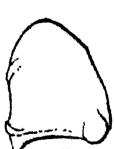
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PLATE IV.

Bostrychini and *Xyloperthini.*

Figs. 43, 44. Larva of *Schistoceros anobioides* Waterh.
    43. Lateral view.
    44. Mandible ; *lm.* fleshy appendage.
Figs. 45, 46. Larva of *Heterobostrychus aequalis* Waterh.
    45. Antenna.
    46. Labrum and clypeus ; *er*, epipharyngeal rod.
Figs. 47-49. Larva of *Heterobostrychus hamatipennis* lesne.
    47. Head.
    48. Antenna.
    49. Maxilla and labium ; *st*, stylet.
Figs. 50, 51. Larva of *Bostrychopsis parallela* Lesne.
    50. Mandible, inner face ; *lm*, vestige of fleshy appendage.
    51. Antenna.
Fig. 52. Larva of *Heterobostrychus pileatus* Lesne, antenna.
Figs. 53, 54. Larva of *Xylothrips flavipes* Ill.
    53. Head.
    54. Antenna.
Figs. 55, 56. Larva of *Xylopsocus capucinus* F.
    55. Antenna.
    56. Maxilla.
Fig. 57. Larva of *Xylodectes ornatus* Lesne, antenna.
Fig. 58. Larva of *Micrapate simplicipennis* Lesne, antenna.

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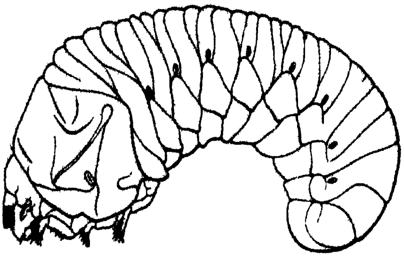
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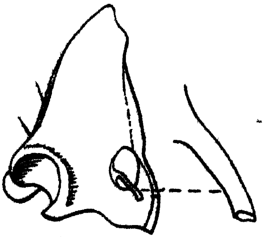
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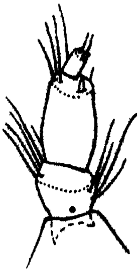
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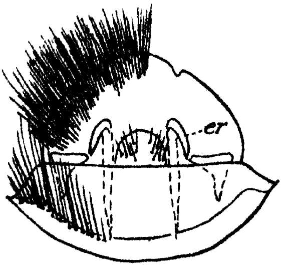

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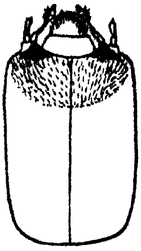
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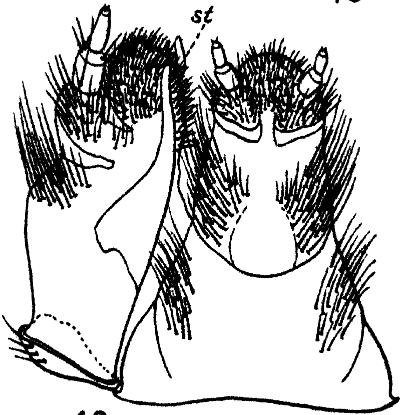

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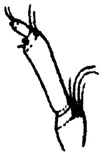
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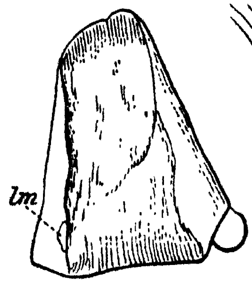

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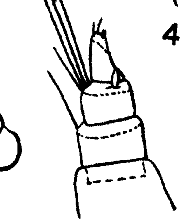
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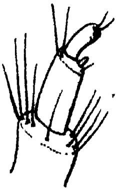
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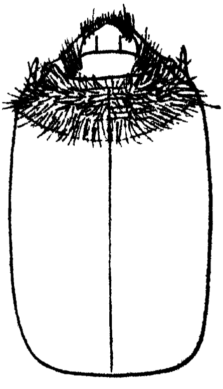
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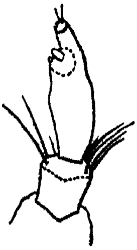
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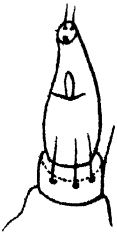
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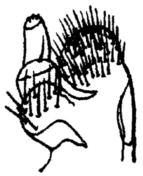
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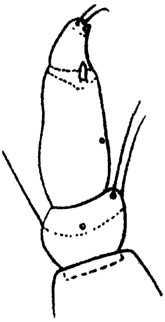
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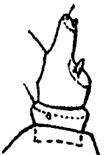
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one third as long as apical segment. Clypeus well developed, with a transverse group of setae on each side. Labrum transverse, the anterior margin with short dense red setae; the posterior margin thickened, brown and connected with two rods which extend back to epistoma; a pair of hook-shaped rods is associated with the posterior margin. Epipharynx with an anterior hairy lobe on each side. Maxilla (fig. 49) with mala stout, with short dense apical setae and stout blackish maxillary stylet; palpiger stout, setose; palp with basal segment longer than wide and slightly longer than the blunt apical segment which is weakly enlarged basally. Labium with wide setose ligula; the two palp segments nearly equal in length; prementum limited posteriorly by a transverse brown line. Mandible short and stout, the apex curved, chisel-shaped; apparently without 'fleshy appendage'. Legs with reddish setae; the anterior pair distinctly stouter than the middle pair which is slightly stouter than the posterior; anterior leg with a straight dark brown acute claw; middle and posterior legs each with a more slender claw. Thoracic spiracle large, twice as wide as the posterior abdominal spiracle and two-thirds as wide as labrum.

HETEROBOSTRYCHUS AEQUALIS WATER.

Larvae were extracted from *Parashorea stellata*, Rangoon, Burma; Dr. Kalshoven also provided specimens from Java.

Larva (Pl. IV, figs. 45, 46).

Length about 11 mm. Length of head capsule about 2·3 mm. Antenna (fig. 45) with second segment stout, widest near the middle, much less than twice as long as wide. Thoracic spiracle small, about one-third as wide as labrum. Labrum and clypeus as in fig. 46.

HETEROBOSTRYCHUS PILEATUS LESNE.

Larvae were extracted from *Garuga pinnata*, Jarwa, U. P.

Larva (Pl. IV, fig. 52).

Length about 12 mm. Length of head capsule about 2·4 mm. Antenna (fig. 52) with second segment about twice as long as wide. Thoracic spiracle large, about two-thirds as wide as labrum.

Xyloperthini.

Mature larvae of this group differ from other Bostrychinae in having no free maxillary stylet (fig. 56). The second and third antennal segments are apparently fused as in the Sinoxylonini, the small conical accessory appendage is retractile. The anterior legs are distinctly stouter than the others; attenuate claws are present on all legs. Maxillary mala setose, some of the apical setae flattened and truncate. Mandibles short and stout, apically rounded. The labrum about twice as wide as long in *Micrapate*, still more transverse in the other species. So far as the larvae are concerned *Xylodectes*, *Xylopsocus* and *Xylothrips* are closely allied and only characters of specific value seem to be present. *Micrapate* is included in this group because the larva has no free maxillary stylet.

The larval characters of *Scobicia declivis* Leconte are described in detail by Boving (1922). The first stage larva of this species differs from the mature larva in having a straight body, rudimentary legs and a median spur on the ninth abdominal segment.

Key to species.

1. Antenna very small, the three segments together shorter than the two-segmented maxillary palp	*Micrapate simplicipennis* Lesne,
Antenna longer than maxillary palp	(2)
2. Basal segment of maxillary palp distinctly shorter than apical segment	(3)
Basal segment of maxillary palp subequal to apical segment	*Xylothrips flavipes* Ill.
3. Segment 2 of antenna only slightly longer than wide	*Xylopsocus capucinus* F.
Segment 2 of antenna much longer than wide .	*Xylodectes ornatus* Lesne.

MICRAPATE SIMPLICIPENNIS LENSE.

(Pl. IV, fig. 58).

Larvae and beetles were obtained from dry wood, Dehra Dun. Length about 5 mm. Head moderately elongate (·90 mm. × ·78 mm.). Antenna (fig. 58) very short, not as long as maxillary palp; the second segment transverse, the third about as long. Apical segment of maxillary palp longer than basal.

XYLOTHRIPS FLAVIPES ILL.

(Pl. IV, figs. 53, 54).

Larvae and bettles from Java were provided by Dr. Kalshoven. The species bores in *Shorea robusta* and other timbers in India. Length about 10 mm. Head (fig. 53) rectangular, elongate (2·0 mm. × 1·6 mm.). Antenna (fig. 54) distinctly longer than maxillary palp, the second segment about twice as long as wide. Basal segment of maxillary palp nearly as wide as long and very nearly as long as apical segment. Thoracic spiracle about two-thirds as wide as labrum.

XYLOPSOCUS CAPUCINUS F.

(Pl. IV, figs. 55, 56).

Larvae and beetles from Java were provided by Dr. Kalshoven. The species occurs in India. Length about 6 mm. Head about 1·2 mm. in length. Antenna (fig. 55) with second segment stout, only slightly longer than wide. Basal segment of maxillary palp (fig. 56) transverse, shorter than second.

Numerous beetles of *X. capucinus* F. and one of *X. radula* Lesne were reared from *Terminalia myriocarpa* from Sadiya, Assam; extracted larvae differ from those described above in having the second antennal segment strongly transverse and may be *X. radula.*

XYLODECTES ORNATUS LESNE.

(Pl. IV, fig. 57).

Larvae were obtained from *Mallotus philippinensis,* Dehra Dun. Length about 6 mm. Head 1·3 mm. in length. Antenna (fig. 57) with second segment about 1·5 times as long as wide. Basal segment of maxillary palp slightly transverse, shorter than second.

Sinoxylonini.

Characters of larvae (*Sinoxylon*) :—Antenna with three segments the basal one short, the second apparently fused with the more slender, digitiform third segment; accessory appendage distinct, elongate conical. Mandible (fig. 42) short and stout, apically gouge-shaped, rounded. Maxillary palps two-segmented, borne on a basal palpiger; maxillary stylet (fig. 39) well developed. Prothorax with a distinct 'lateral rod' on each side. Anterior abdominal terga with three transverse subdivisions. Spiracles oval the posterior pair small. Anterior legs much stouter than the others, all with claws.

The head is almost rectangular, more or less rugulose anteriorly and brownish near the mandibular articulations. Clypeus with a few setae on each side. Labrum transverse, anteriorly setose. Epipharynx soft skinned, the epipharyngeal rods distinct.

The larva of this genus are very much alike, but specific differences are found in the second antennal joint which varies from transverse (*oleare, capillatum*) to twice as long as wide (*sudanicum*).

S. CAPILLATUM LESNE.

Larva : Length of head 1·8 mm. Second segment of antenna short and stout, not longer than wide. Maxillary palp with basal segment weakly transverse, subequal in length to second which is less than twice as wide as long. Claw of metathoracic legs very fine, acuminate, brownish. (Larvae from dry stems, Dehra Dun, J. C. M. G.).

S. OLEARE LESNE.

Larva : Length of head 1·4 mm., width 1·0 mm. Second segment of antenna (fig. 40) short and stout, hardly longer than wide. Maxillary palp with basal segment transverse, shorter than second which is less than twice as long as wide. Claw of metathoracic leg relatively short and stout, not acuminate. (Larvae from a dry climber, Dehra Dun, J. C. M. G.).

S. SUDANICUM LESNE.

Larva : Length of head 1·8 mm. Second segment of antenna (fig. 37) elongate, about twice as long as wide. Both segments of maxillary palp elongate, subequal in length, the apical one twice as long as wide. Claw of metathoracic leg fine, acuminate. (Larvae from dry *Mallotus philippinensis*, Dehra Dun, J. C. M. G.).

S. ATRATUM LESNE.

Larva: Length of head 1·7 mm. Second segment of antenna (fig. 38) elongate, but less than twice as long as wide. Basal segment of maxillary palp (fig. 39) transverse, distinctly shorter than apical segment which is less than twice as long as wide. Claw of metathoracic leg subacuminate. Larvae from dry sticks, Coimbatore, Madras, J. C. M. G.).

S. ANALE LESNE.

Larva : Length of head 1·8 mm. Second segment of antenna about 1·5 times as long as wide. Basal segment of maxillary palp weakly transverse, shorter than apical segment which is less than twice as long as wide. Claw of metathoracic leg very fine, acuminate. (Larvae from Java, L. G. E. Kalshoven and from Dehra Dun, J. C. M. G.).

S. CRASSUM LESNE.

Larva: Length of head 2·4 mm; width 1·8 mm. Second segment of antenna (fig. 41) about three-fifths as wide as long. Basal segment of maxillary palp subequal to second which is less than twice as long as wide. Mandible as in fig. 42. Claw of metathoracic leg not acuminate, comparatively stout, brownish (Larvae from fuel wood, Dehra Dun, G. D. Bhasin).

LITERATURE.

Altson, A. M. 1922. On the young larvae of *Lyctus brunneus* Steph. Ann. App. Biol. **9**: 187-196.

Altson, A. M. 1923. On the method of oviposition and the egg of *Lyctus brunneus* Steph. Journ. Linn. Soc. Zool. **35**: 217-227.

Beeson, C. F. C. 1919. The food plants of Indian Forest Insects, Indian Forester **45**: 51-55.

Beeson, C. F. C. 1933. Lyctus Beetles in India. Indian Forester, **59**: 158-164.

Böving, A. G. 1922. Taxonomy and Morphology of the Larval Stages of *Scobicia declivis* Leconte. Bull. 1107, U. S. Dept. Agric. (Appendix), 49-56, 2 plates.

Böving, A. G. and F. C. Craighead 1931. An illustrated synopsis of the principal larval forms of the order Coleoptera. Entomologica Americana **11**.

Kojima, T. 1932. Beiträge zur Kenntnis von *Lyctus linearis* Goeze. Ztschr. f. Angew. Ent. **19**: 325-356.

Lesne, P. 1920. Classification des Coléoptères Xylophages de la famille des Bostrychides. Assoc. franc. pour l'avanc. des Sciences, Congress de Strasbourg.

Lesne, P. 1924. Les coléoptères Bostrychides le l'Afrique tropicale française. Paris.

Munro, J. W. 1916. The larvae of the furniture beetles of the families Anobiidae and Lyctidae. Proc. Roy. Phys. Soc. Edin. **19**: 220-236.

Saalas, U. 1923. Die Fichtenkäfer Finnlands, **2**.

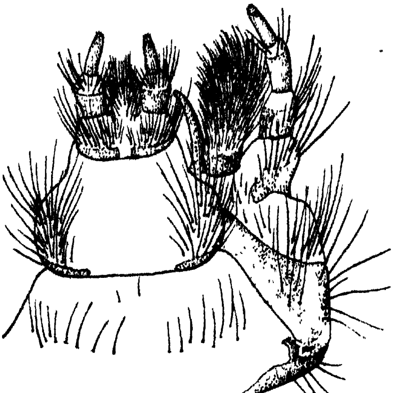
Snyder, T. S. 1916. Egg and manner of oviposition of *Lyctus planicollis* Journ. Agr. Res. **6**: 273-276.

PLATE 1.

Apoleoninae ; Psoinac.

Figs. 1-6. Larva of *Apoleon edax* Gorham.
1. Labium and left maxilla.
2. Prothoracic leg.
3. First and second abdominal segments, lateral view.
4. Mandible ; *lm*, fleshy appendage.
5. Thoracic spiracle.
6. Antenna.

Figs. 7-12. Larva of *Heterarthron feanus* Lesne.
7. Larva, lateral view.
8. Mandible ; *lm*, fleshy appendage.
9. Antenna : *bm*, basal connecting skin.
10. Labrum and clypeus.
11. Epipharynx.
12. Legs : *a*, prothoracic ; *b*. mesothoracic ; *c*, metathoracic.



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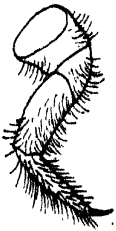

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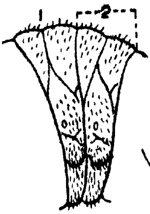

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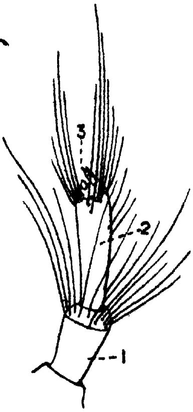

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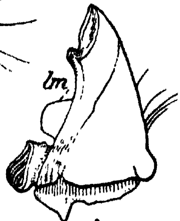

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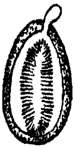

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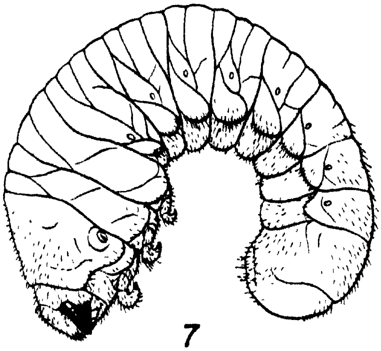

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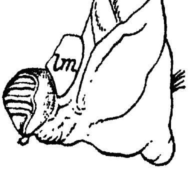

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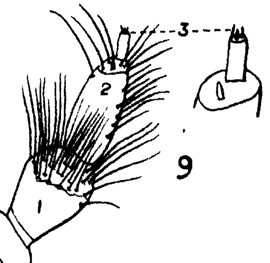

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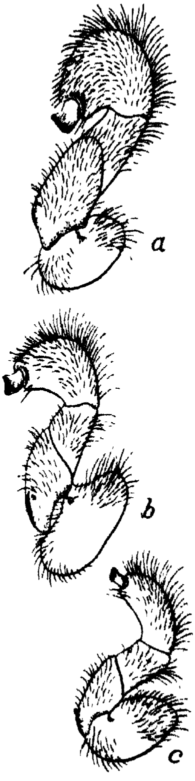

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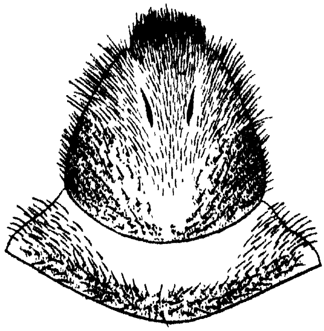

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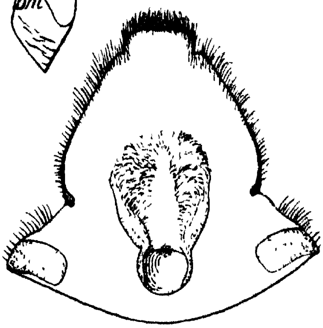

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PLATE II.

Lyctinae.

Figs. 13-14. Larva of *Lyctoxylon japonum* Reitt.
    13. Lateral view.
    14. Antenna.

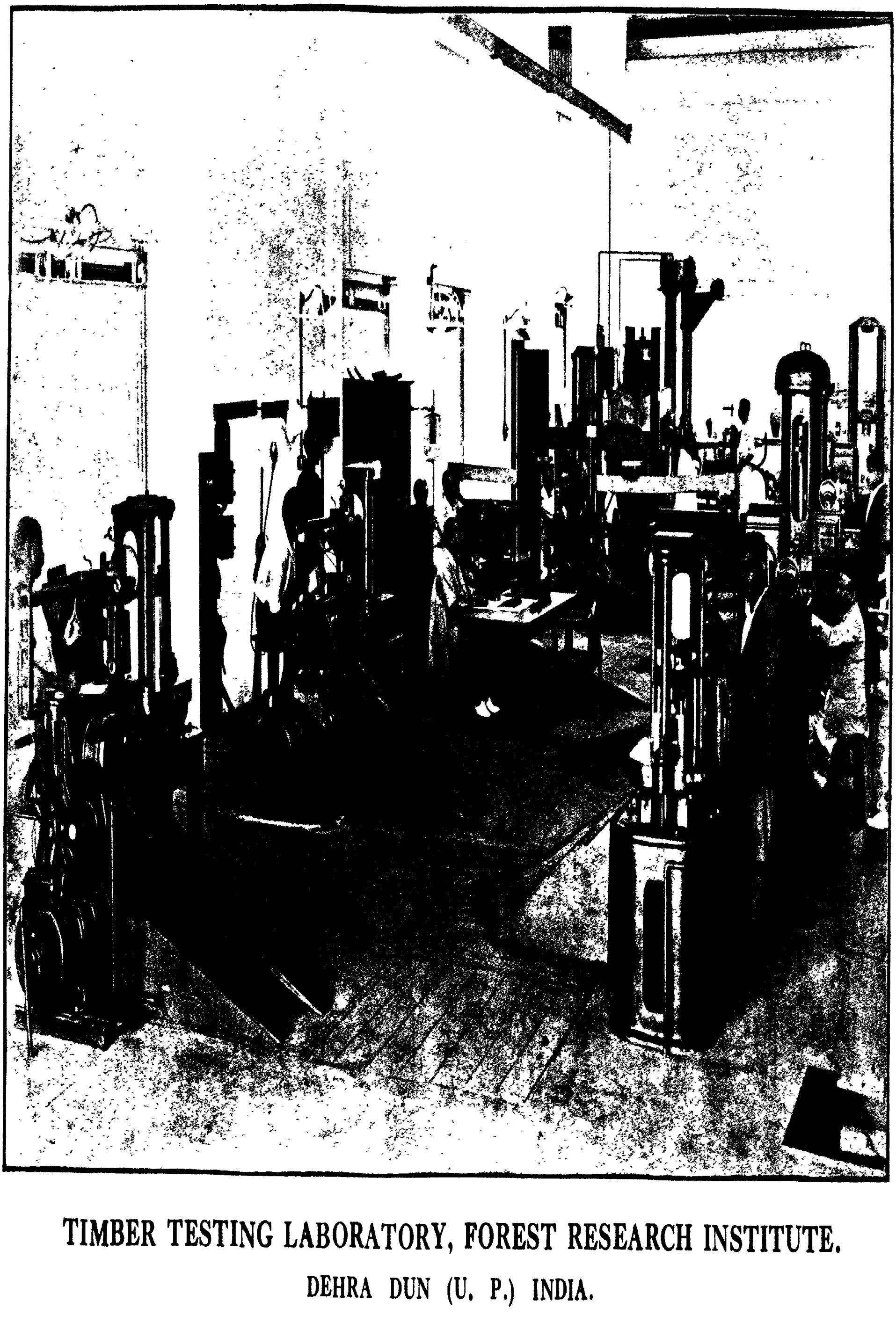
Figs. 15-19. Larva of *Lyctus africanus* Lesne.
    15. Antenna.
    16. Head.
    17. Mandible ; *lm*. fleshy appendage.
    18. Epipharynx.
    19. Spiracles of thorax, first and eighth abdominal segments.

Fig. 20. Larva of *Lyctus fuscus* L., antenna.

Figs. 21-23. Larva of *Trogoxylon auriculatum* Lesne.
    21. Antenna.
    22. Mandible.
    23. Spiracles of thorax, first and eighth abdominal segments.

Fig. 24. Larva of *Minthea rugicollis* Walk, antenna.

Figs. 25-27. Larva of *Lyctus brunneus* Steph.
    25. Spiracle of first abdominal segment.
    26. Antenna.
    27. Maxilla and labium, *st*, maxillary stylet.



TIMBER TESTING LABORATORY, FOREST RESEARCH INSTITUTE.

DEHRA DUN (U. P.) INDIA.

INDIAN FOREST RECORDS

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THE PHYSICAL AND MECHANICAL PROPERTIES OF WOODS GROWN IN INDIA.

THIRD INTERIM REPORT ON PROJECT I.

(Tests on Small Clear Specimens including results of work done up to the end of 1932.)

BY

V. D. LIMAYE, B.E. (Mech.).

PART I.

1. INTRODUCTION.

Among Indian timber species, teak has held and still holds a place of prime importance. It can be obtained in large sizes of from 20 to 30 inches square and 30 ft. or more in length. Larger sizes up to 40 inches square and 60 to 75 ft. long are not uncommon. Teak is a useful wood in every phase of building construction and in railway coach work, and is exported in large quantities for ship building. The wood is chiefly valued on account of its excellent retention of shape and its high resistance to decay and insect attack. It is, however, grown on a commercial scale in certain zones of forests only, and extraction and transportation charges, which are often very high, increase its price considerably in other parts of India where it does not grow.

Indian forests do, however, produce a very large number of other species that are suitable for many purposes for which teak is used. These woods are usually employed locally in cheap dwellings or temporary structures, but teak is the timber most used in structures of any importance. The high cost of teak has, however, led to a demand for other species, and engineers have begun to accept them for work of importance.

Some species like Andaman *padauk* (*Pterocarpus dalbergioides*) have already established their worth even in foreign markets.

In the search for substitutes for teak, the possession of knowledge as to the merits and demerits of other species became of paramount importance. The qualities of teak have long been known through continued usage, but the qualities of other species could only be determined after many years of study and research. Such work requires the expenditure of much money and high technical skill on the part of the officer conducting it, and can only be accomplished through Government agency. This fact was recognized by the Government of India who inaugurated the Timber Testing Section in 1921 under the able direction of Mr. L. N. Seaman. The results of ten years of patient and continuous work are now presented to the public, and test data on 120 species from different parts of India are included in this report. With these data it is now possible to compare the properties of these woods with teak, and with each other, and thereby to arrive at sound conclusions as to the best timber to use for any specific purpose.

The information given in this report is also of particular service in another direction. India imports every year enormous quantities of small articles manufactured from foreign timbers. To take for instance only a single example, the East Indian Railway purchases three to four lakhs of tool handles annually, and the requirements of all the other Indian railways, docks, mines, mills, etc., are estimated to run into millions. Most of the tool handles used are of imported ash or hickory. It is possible to select, by the aid of test data, a dozen indigenous species which can probably be substituted for the imported timbers. Special tests made on these lines showed that the following species *viz. Heritiera minor* (*sundri*), *Sageraea listeri* (*chooi*), *Berrya ammonilla* (Trincomalee wood), *Anogeissus latifolia* (axlewood), *Schleichera trijuga* (*kusum*), *Anogeissus acuminata* (*yon*), *Grewia tiliaefolia* (*dhaman*), *Olea ferruginea* (Indian olive or *kow*), and *Parrotia jacquemontiana* (*parrotia*) were all suitable for hammer handles. These species have since been recommended for inclusion in the Railway Board specifications for tool handles.

Other articles such as bobbins, weft pirns, picker arms, shuttles, etc., are imported in large quantities every year for which suitable substitutes of Indian woods could be found. There is, however, a certain amount of prejudice among the users of these articles against Indian woods, probably because some of the woods that had been tried before, without having reliable knowledge of their properties, were found to be unsuitable.

In these days of economic stress, when no efforts should be spared to exploit the resources of the country and to utilise indigenous products, this report will perhaps serve a useful purpose if the results presented help to remove these prejudices and make the substitution of Indian timbers for imported wood easier.

It has been found by experience that the majority of lay readers, businessmen and forest officers have not the time nor the patience to read through long technical and theoretical reports, but are, nevertheless, interested as practical men in knowing the merits of one species over another for a particular purpose. They do not wish to know the actual stresses or the quantitative data, but require merely to compare the different woods in some simple manner. The first part of this report which is called 'Popular Treatment' is especially written for such readers. The subject is here presented in as simple and non-technical a form as possible, reserving all technical discussions and methods of calculation for the second part which is entitled "Technical Treatment". In this part the more advanced technical readers will find detailed information about timber testing and the data necessary for designing structures and working out strength figures for all purposes.

Strength data presented in this report have been revised and brought up-to-date and supersede similar data published before.

2. REVIEW OF WORK DONE.

The First Interim Report on the work of the Section of Timber Testing was published in 1924 and presented the results obtained up to the end of 1922. The Second Interim Report was published in 1926 and gave the results of tests up to the end of 1924. Up to that time, only 18 species had been tested in the green condition, and 9 each in air-dry and kiln-dry conditions. After 1924, the Timber Testing Section was considerably expanded and more rapid progress was made. This Third Interim Report presents an account of the progress made up to the end of March 1932. Altogether, 146 consignments have been tested each in green, air-dry and kiln-dry conditions, and their physical and mechanical properties have been computed. The results of tests in the green and air-dry conditions are given in the table of results in Part II. The results in the kiln-dry condition are not given in this report as kiln seasoning has still only a limited application in India. Any one interested in kiln dried material can, however, obtain the test results on application to the Forest Research Institute, Dehra Dun.

The material for test was collected from all parts of India, the contribution from each province being as follows :—

	consignments.*
Burma	28
Madras	26
United Provinces	24
Bengal	13
Andamans	12
Central Provinces	11
Bihar and Orissa	10
Assam	7
Punjab	6
Bombay	6
Kashmir State	2
Chamba State	1
TOTAL	146 consignments.

In the Tables, the strengths of 140 consignments only are given, those that were incomplete and others that reached Dehra Dun in a damaged condition having been omitted.

The number of different species of indigenous woods tested is 120.

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*A " consignment " consists of five logs each nine feet long.

Most species have been chosen for test from the provinces where they are most abundant or commercially important. But it is the intention later to test each species separately from all the provinces where it is available in commercial quantities (as shown in the Appendix, Table No. 2) as strength is often affected by local conditions. For instance, teak from the Central Indian region is weaker than teak from Burma or Malabar, but it often has a more ornamental appearance.

Thanks are due to the different provinces that have taken an interest in the work and have encouraged us by sending test material. It will be seen from the above list of contributions that Burma, Madras, and the United Provinces have sent and are still sending many species for test. From the data obtained from these tests they have been able to put on the market, for constructional purposes, timbers that were hitherto used only for minor works.

Table No. 2 in the Appendix shows the species of timber received for test at Dehra Dun, and the progress of the work. It also indicates the provinces in which the timber is of economic importance.

3. EXPLANATION AND TABLE OF SUITABILITY FIGURES.

As stated in the Introduction, although the tables of strengths given at the end are of value to engineers, they convey little information to persons who have not acquired a technical training. In order to make the results of testing more serviceable to the timber producer and timber user in general, Table No. 1 has been prepared. This table affords an easy comparison between different woods, and transforms the more technical data into a form which is at once intelligible to the layman.

How Table 1 is calculated.

For this purpose, values of eight of the most important properties are given in this table. These values are called "*suitability figures*" and are intended to indicate the suitability of a timber for particular uses. The calculation of each figure is based on all the strength functions bearing upon the usefulness of the timber for the particular purpose under consideration. Taking for instance the property "strength as a beam", three functions, *viz.* modulus of rupture and fibre stress at elastic limit in static bending, and fibre stress at elastic limit in impact bending, are combined, after multiplying them by adjusting and weighting factors. Suitability figures are calculated in this way for every species tested, and the values expressed as percentages of the corresponding values for teak which is taken as the basis of comparison because it is the most widely used, important, and best known Indian timber. A discussion of the adjusting and weighting factors referred to above, and sample calculations, are given in detail in Part II. It may here be sufficient to point out that the determination of these factors is the result of long experience and careful study of the properties of timber.

Limitations of suitability figures.

The values given in this table are not concrete but are only index numbers. Teak is taken as 100 in every case. When in the table the suitability figure for strength as a beam for *Acacia arabica* (*babul*) is given as 120 it means that *babul* is 20 per cent stronger than teak in this particular respect. In the same way, the suitability figure of 70 for retention of shape means that *babul* is inferior in this respect, keeping its shape only 70 per cent as well as teak. Other properties are similarly indicated.

It will be noted that the figures given in Table 1 are useful for comparison only and give the relative position of a particular species among other woods considered with regard to any special use. They must not, therefore, be used for engineering calculations. For this purpose the strength functions given in Table 3 in Part II may be used with proper safety factors. A table called "Safe Working Stresses" has been prepared for engineers' use in structural design and is published in the report on "Strength Tests of Indian Timbers in Structural Sizes" (Indian Forest Record, Vol. XVII, Part VII, 1933).

It must be remembered that the values given in this publication refer to strength properties only. Although strength is an essential quality, there are others such as seasoning properties, easy workability, durability, appearance, availability in particular localities, cost, etc., which should also be studied. The table of suitability figures enables the best selection to be made, with regard to strength, from among the available species which are satisfactory in other respects.

Explanation of the suitability table.

In column 1, the serial number is given, the species being arranged in alphabetical order. The name of the species is given together with the trade name or common vernacular name in the second column, and the locality from which material for test was obtained is shown in the third column.

The weight of the wood as compared to teak (both at 12 per cent moisture content), is given in column 4.

In column 5, the figures listed show the strength of the wood as compared with teak when used as a beam. Three different properties have been taken into consideration as stated above for deriving these figures.

In column 6, figures for the stiffness of wood when used as a beam are given. If the figures are high, they indicate that the wood is stiff, *i.e.*, that its deflection under a given load is comparatively small. Moduli of elasticity in static bending and in impact bending have been employed in this case.

In column 7, values for the suitability of wood when used as a column are given. Compressive stress at elastic limit and maximum crushing stress in compression parallel to grain, and modulus of elasticity in static bending, have been considered in computing these figures.

In column 8, the shock resisting ability of the different woods is given. For certain purposes such as poles of vehicles and implements, handle etc., woods having great resilience are required. Such woods are indicated by the figures under this heading. Work to maximum load and total work in static bending, and the maximum height of drop in impact bending have been made use of in this case.

In column 9, the ability of different woods to retain their shape after seasoning is stated in comparison with teak, which is superior to almost all other woods in this respect. Shrinkage from green to oven-dry condition in volume and in the radial and tangential directions has been taken into account here, together with the ratio of tangential to radial shrinkage.

In column 10, comparative figures for shear are given, calculated from values of radial and tangential shearing strengths.

In column 11, comparative values for hardness are shown. Compressive stress at elastic limit in compression perpendicular to grain, and hardness of radial, tangential, and end surfaces have been used in calculating these figures.

The suitability figures are calculated by combining the results of tests in both the green and air-dry conditions as shown in Chapter 3, Part II. Those for *Artocarpus chaplasha* and *Casuarina equisetifolia* are based on tests of material in the green condition only, as strength values in the air-dry condition are not yet available for these species. These values are therefore tentative and are printed in italics to distinguish them from the values for other species which are obtained from more complete data.

The values for shock resisting ability for *Anogeissus latifolia* from Madras and for *Dipterocarpus tuberculatus* from Burma are not given in the table as data are not yet available.

TABLE No. 1.

Relative Suitability of woods grown in India.

Teak taken as 100 in every case.

Serial No. 1	Species. 2	Locality 3	Weight. 4	Strength as a beam. 5	Stiffness as a beam. 6	Suitability as a post 7	Shock resisting ability. 8	Retention of shape. 9	Shear. 10	Hardness. 11
	Tectona grandis (teak).	Burma and Malabar.	100	100	100	100	100	100	100	100
1	*Abies pindrow* (Himalayan silver fir)	Simla, (Punjab) . .	75	70	85	80	75	65	80	65
2	*Acacia arabica (babul)* . . .	Hyderabad, (Sind) .	120	120	95	105	170	70	180	185
3	*Acrocarpus fraxinifolius (mundani)*	Malabar, (Madras) .	100	100	105	100	110	80	135	105
4	*Adina cordifolia (haldu)* . .	Haldwani, (U P.) .	95	75	75	80	80	80	110	110
5	*Adina cordifolia (haldu)* . .	South Coimbatore, (Madras).	100	75	80	75	85	85	100	100
6	*Adina cordifolia (haldu)* . .	Saranda, (B. & O.) .	100	95	85	90	105	75	120	115
7	*Ægle marmelos (bel)* . . .	Gonda, (U. P.) . .	130	80	80	80	90	60	165	185
8	*Albizzia lebbek (kokko)* . . .	South Andaman . .	95	85	100	90	85	80	125	100
9	*Albizzia procera (white siris)* . .	Dehra Dun, (U. P) .	95	85	80	85	140	75	130	105
10	*Alstonia scholaris (shaitan wood)* .	North Mangalore, (Madras)	60	50	55	50	35	85	60	40
11	*Anogeissus acuminata (yon)* . .	Pyinmana, (Burma) .	130	120	120	115	150	60	155	175
12	*Anogeissus latifolia* (axle-wood) .	Dehra Dun, (U P) .	130	95	90	80	165	65	135	150
13	*Anogeissus latifolia* (axle-wood) .	South Coimbatore, (Madras).	140	105	105	95	†	65	135	175

† Data not yet available.

TABLE No. 1.

Relative Suitability of woods grown in India—contd.

Serial No. 1	Species. 2	Locality. 3	Weight. 4	Strength as a beam. 5	Stiffness as a beam. 6	Suitability as a post 7	Shock resisting ability. 8	Retention of shape. 9	Shear. 10	Hardness. 11
	Tectona grandis (teak)	Burma and Malabar.	100	100	100	100	100	100	100	100
*14	*Artocarpus chaplasha (chaplash)* .	Lakhimpur, (Assam) .	75	80	75	80	75	85	100	80
15	*Artocarpus hirsuta (aini)* . .	South Mangalore, (Madras).	90	90	90	95	90	95	90	95
16	*Bassia latifolia (mahua)* . .	Jubbulpore, (C. P.) .	135	75	80	75	100	50	120	165
17	*Berrya ammonilla* (Trincomalee wood).	Insein, (Burma) . .	140	110	115	110	165	55	180	180
18	*Bischofia javanica* (bishop wood) .	South Coimbatore, (Madras).	110	70	80	70	65	85	100	95
19	*Bombax insigne (didu)* . .	South Andaman . .	55	45	50	50	50	90	45	35
20	*Bombax malabaricum (semul)* .	Dehra Dun, (U. P.) .	55	45	45	45	55	90	85	35
21	*Boswellia serrata (salai)* . .	Hazaribagh, (B. & O.) .	80	55	60	55	65	90	85	60
22	*Calophyllum tomentosum* (Syn. *elatum*) (*poon*).	South Coimbatore, (Madras).	90	85	95	85	85	65	105	85
23	*Calophyllum tomentosum* (Syn. *elatum*) (*poon*).	South Kanara, (Bombay)	95	90	90	85	80	65	85	95
24	*Calophyllum wightianum (poon)* .	South Kanara, (Bombay)	100	80	80	80	90	65	110	110
25	*Canarium euphyllum (white dhup)* .	South Andaman . .	60	50	70	55	55	70	70	40
26	*Carapa moluccensis (pussur)* . .	Tavoy, (Burma) . .	115	95	95	100	95	80	100	130
27	*Careya arborea (kumbi)* . .	Haldwani, (U. P.) .	130	80	80	80	110	50	135	150

1	2	3	4	5	6	7	8	9	10	11
*28	*Casuarina equisetifolia* (Australian beefwood).	Puri, (B. & O.) . .	*115*	*85*	*100*	*85*	*135*	*50*	*150*	*125*
29	*Cedrela serrata* (*toon*) . . .	Maymyo, (Burma) .	80	75	85	85	85	75	115	80
30	*Cedrela toona* (*toon*) . . .	Dehra Dun, (U. P.) .	70	55	65	60	60	65	100	65
31	*Cedrus deodara* (deodar) . .	Simla, (Punjab) . .	80	80	80	85	60	85	90	70
32	*Chloroxylon swietenia* (East Indian satin wood).	Vizagapatam, (Madras) .	155	110	105	115	115	70	180	195
33	*Chukrasia tabularis* (chickrassy) .	Buxa, (Bengal) . .	95	75	80	70	90	75	120	110
34	*Cryptomeria japonica* (*dhupi*) .	Darjeeling, (Bengal) .	40	25	20	20	35	65	55	20
35	*Cullenia excelsa* (*karani*) . .	Malabar, (Madras) .	90	95	105	100	105	70	70	85
36	*Cupressus torulosa* (Himalayan cypress).	Garhwal, (U. P.) . .	75	70	80	75	60	85	65	60
37	*Cynometra polyandra* (*ping*) . .	Sylhet, (Assam) . .	130	115	115	115	155	55	140	175
38	*Dalbergia latifolia* (Indian rosewood).	South Chanda, (C. P.) .	130	90	90	85	125	80	135	160
39	*Dalbergia sissoo* (*sissoo*) .	Dehra Dun, (U. P.) .	120	95	90	85	140	80	125	130
40	*Dalbergia sissoo* (*sissoo*) . .	Hazaribagh. (B. & O.) .	115	90	80	85	140	90	145	140
41	*Dichopsis elliptica* (*pali*) .	Malabar, (Madras) .	90	90	105	95	100	65	85	90
42	*Dillenia indica* (*chalta*) . .	Chittagong, (Bengal) .	95	80	80	80	85	55	95	80
43	*Dillenia pentagyna* (*dillenia*) . .	Buxa, (Bengal) . .	90	80	75	70	75	65	110	90
44	*Diospyros melanoxylon* (ebony) .	Nagpur, (C. P.) . .	120	75	75	75	115	60	110	115
45	*Dipterocarpus alatus* (*gurjun*) .	Insein, (Burma) . .	100	90	100	90	95	60	105	85
46	*Dipterocarpus griffithii* (*gurjun*) .	Insein, (Burma) . .	110	105	120	110	100	45	110	95
47	*Dipterocarpus griffithii* (*gurjun*) .	North Andaman . .	110	85	100	90	80	45	100	85
48	*Dipterocarpus kerrii* . . .	Mergui, (Burma) . .	115	95	125	100	115	45	105	85

* Based on tests of green material only.

TABLE No. 1.

Relative Suitability of woods grown in India—contd.

Serial No. 1	Species. 2	Locality. 3	Weight. 4	Strength as a beam. 5	Stiffness as a beam. 6	Suitability as a post. 7	Shock resisting ability. 8	Retention of shape. 9	Shear. 10	Hardness. 11
	Tectona grandis (teak).	Burma and Malabar	100	100	100	100	100	100	100	100
49	*Dipterocarpus macrocarpus* (*hollong*)	Lakhimpur, (Assam) .	105	100	120	105	105	50	105	95
50	*Dipterocarpus tuberculatus* (*eng*) .	Insein, (Burma) . .	125	115	120	100	†	55	130	135
51	*Dipterocarpus turbinatus* (*gurjun*) .	Insein, (Burma) . .	115	105	125	100	115	55	90	105
52	*Duabanga sonneratioides* (*lampatti*)	Kurseong, (Bengal) .	70	60	70	65	65	75	75	60
53	*Dysoxylum malabaricum* (white cedar).	South Coimbatore, (Madras).	110	85	95	90	120	60	115	95
54	*Eugenia gardneri* (*jaman*) . .	South Mangalore. (Madras).	140	95	110	100	105	50	125	150
55	*Eugenia jambolana* (*jaman*) . .	Gonda. (U. P.) . .	115	90	100	95	100	60	130	120
56	*Garuga pinnata* (*garuga*) . .	Dehra Dun, (U. P.) .	85	70	65	65	80	85	115	85
57	*Gmelina arborea* (*gumhar*) . .	Haldwani, (U. P.) .	75	55	60	55	85	85	90	70
58	*Gmelina arborea* (*gumhar*) . .	Insein, (Burma) . .	70	60	70	60	70	85	80	60
59	*Grewia tiliæfolia* (*dhaman*) . .	Malabar, (Madras) .	115	110	125	125	145	60	140	155
60	*Hardwickia binata* (*anjan*) . .	Nimar, (C. P) . .	125	75	60	70	125	90	145	180
61	*Heritiera minor* (*sundri*) . .	Delta, (Burma) . .	150	110	130	110	180	45	150	175
62	*Heterophragma adenophyllum* (Karen wood).	Pyinmana, (Burma) .	125	105	110	120	115	65	125	180
63	*Holoptelea integrifolia* (Indian elm)	Dehra Dun, (U. P.) .	85	65	65	65	100	80	95	80
64	*Homalium tomentosum* (Burma lance wood).	Pyinmana, (Burma) .	135	105	115	110	130	55	160	175

1	2	3	4	5	6	7	8	9	10	11
65	*Hopea glabra* (*kong*) . . .	Palghat, (Madras) .	160	125	130	130	155	60	180	225
66	*Hopea odorata* (*thingan*) . .	South Tenasserim, (Burma).	110	100	100	95	100	75	110	130
67	*Hopea parviflora* (*hopea*) . .	South Mangalore, (Madras)	135	120	120	120	130	65	155	200
68	*Hymenodictyon excelsum* (*kuthan*) .	Ramnagar, (U. P.) .	70	50	55	50	55	75	75	50
69	*Juglans fallax* (walnut) . .	Jhelum valley, (Kashmir) low elevation.	85	80	90	75	105	65	95	70
70	*Juglans fallax* (walnut) . .	Jhelum valley, (Kashmir) high elevation.	80	70	70	65	90	75	90	65
71	*Lagerstrœmia flos-reginæ* (*jarul*) .	Chittagong, (Bengal) .	95	80	85	75	85	65	100	105
72	*Lagerstrœmia hypoleuca* (Andaman *pyinma*).	North Andaman . .	90	80	80	75	85	70	100	80
73	*Lagerstrœmia microcarpa* (*benteak*)	North Kanara, (Bombay)	105	95	105	95	100	60	115	120
74	*Lagerstrœmia parviflora* (*lendi*) .	Dehra Dun, (U. P.) .	105	90	100	95	120	60	135	110
75	*Lagerstrœmia tomentosa* (*leza*) .	Pyinmana, (Burma) .	95	90	100	95	95	70	120	100
76	*Lannea grandis* (*jhingan*) . .	Dehra Dun, (U. P.) .	80	55	50	50	75	85	80	70
77	*Machilus macrantha* (ladder wood).	North Mangalore, (Madras).	75	60	65	60	70	75	80	55
78	*Machilus odoratissima* (ladder wood).	Kurseong, (Bengal) .	100	80	95	85	90	60	120	95
79	*Mangifera indica* (mango) . .	Puri, (B. & O.) . .	95	75	80	75	100	95	105	90
80	*Melanorrhœa usitata* (*thitsi*) . .	Meiktila, (Burma) .	125	70	90	85	55	80	105	150
81	*Mesua ferrea* (*mesua*) . . .	Sibsagar, (Assam) .	140	145	150	150	160	55	145	215
82	*Michelia cathcartii* (*tita champ*) .	Kurseong, (Bengal) .	75	65	90	75	75	65	95	55
83	*Michelia champaca* (*champak*) .	Kurseong, (Bengal) .	70	70	75	70	75	90	85	65
84	*Michelia excelsa*	Kurseong, (Bengal) .	75	75	90	80	75	65	65	60
85	*Mitragyna diversifolia* (*binga*) .	Pyinmana, (Burma) .	95	95	85	90	105	65	110	105

† Data not yet available.

TABLE No. 1.

Relative Suitability of woods grown in India— contd.

Serial No. 1	Species. 2	Locality. 3	Weight. 4	Strength as a beam. 5	Stiffness as a beam. 6	Suitability as a post. 7	Shock resisting ability. 8	Retention of shape. 9	Shear. 10	Hardness. 11
	Tectona grandis (teak)	Burma and Malabar	100	100	100	100	100	100	100	100
86	*Mitragyna parvifolia* (*kaim*)	Haldwani, (U. P.)	95	75	70	75	95	65	110	100
87	*Morus alba* (mulberry)	Changamanga, (Punjab)	100	85	85	80	135	65	145	125
88	*Morus serrata* (mulberry)	Chamba State, (Punjab)	95	70	75	60	130	80	115	90
89	*Parashorea stellata* (Tavoy wood)	Tharrawaddy, (Burma)	105	90	115	105	95	55	115	85
90	*Parishia insignis* (*red dhup*)	South Andaman	70	50	75	55	50	65	75	40
91	*Pentace burmanica* (*thitka*)	Burma	95	95	95	95	100	75	110	110
92	*Pentacme suavis* (Burma *sal*)	Pyinmana, (Burma)	135	115	125	115	125	60	130	155
93	*Phœbe hainesiana* (*bonsum*)	Nowgong, (Assam)	80	80	80	80	80	75	95	70
94	*Picea morinda* (Himalayan spruce)	Simla, (Punjab)	65	60	75	75	55	70	70	55
95	*Pinus excelsa* (blue pine)	Rawalpindi, (Punjab)	75	55	60	60	55	75	65	40
96	*Pinus longifolia* (*chir*)	Rawalpindi, (Punjab)	90	70	85	80	80	65	90	70
97	*Pinus longifolia*, twisted (*chir*)	Ranikhet, (U. P.)	75	50	60	55	45	75	85	50
98	*Pinus longifolia* (*chir*)	Ranikhet, (U. P.)	75	65	80	70	80	70	70	50
99	*Pinus longifolia*, twisted (*chir*)	Dehra Dun, (U. P.)	90	65	80	70	80	65	95	65
100	*Planchonia andamanica* (*red bombway*).	South Andaman	135	100	115	105	105	50	110	145
101	*Podocarpus neriifolia* (*thitmin*)	South Andaman	80	75	80	85	55	80	80	75
102	*Polyalthia fragrans*	Malabar, (Madras)	75	70	80	75	85	70	70	60

1	2	3	4	5	6	7	8	9	10	11
103	*Pterocarpus dalbergioides* (Andaman *padauk*).	North Andaman . .	105	100	105	105	100	105	115	180
104	*Pterocarpus macrocarpus* (Burma *padauk*).	Mogok, (Burma) . .	125	135	120	130	160	90	145	195
105	*Pterocarpus marsupium* (*bijasal*) .	Belgaum, (Bombay) .	115	105	95	95	135	75	115	185
106	*Pterospermum acerifolium* (*hatti-paila*).	Buxa, (Bengal) . .	90	85	85	85	125	80	105	100
107	*Sageraea listeri* (*chooi*) . . .	South Andaman . .	125	140	125	130	235	60	180	170
108	*Schima wallichii* (needle wood) .	Buxa, (Bengal) . .	100	80	95	80	90	50	125	85
109	*Schleichera trijuga* (*kusum*) . .	Pyinmana, (Burma) .	160	135	140	140	155	50	185	260
110	*Shorea assamica* (*makai*) . .	Lakhimpur, (Assam) .	80	65	80	75	75	65	110	75
111	*Shorea obtusa* (Burma *sal*) . .	Pyinmana, (Burma) .	155	135	150	140	155	55	150	195
112	*Shorea robusta* (*sal*) . . .	Balaghat, (C. P.) . .	120	105	110	105	115	60	110	120
113	*Shorea robusta* (*sal*) . . .	Kalimpong and Jalpaiguri (Bengal).	180	120	130	120	145	55	140	150
114	*Shorea robusta* (*sal*) . . .	North Kheri, Gorakhpur, and Haldwani, (U. P.)	130	110	110	110	145	60	150	165
115	*Sonneratia apetala*, (*keowra*) . .	Sunderbans, (Bengal) .	90	70	70	65	90	70	95	95
116	*Stereospermum chelonoides* (*padri*) .	Buxa, (Bengal) . .	105	80	80	80	110	75	130	105
117	*Stereospermum suaveolens* (*padal*) .	Dehra Dun, (U. P.) .	105	85	80	75	145	70	105	105
118	*Swintonia floribunda* (*taung thayet*).	Insein, (Burma) . .	95	75	95	80	80	75	110	70
119	*Tectona grandis* (teak) . . .	Malabar, (Madras) .	100	90	95	95	85	85	110	105
120	*Tectona grandis* (teak) . . .	South Chanda, (C P.) .	90	75	70	70	65	110	95	85
121	*Tectona grandis* (teak) . . .	Zigon, (Burma) . .	95	100	100	100	105	110	90	90
122	*Tectona grandis* (teak) (girdled) .	Zigon, (Burma) . .	100	105	105	105	105	110	100	105
123	*Tectona grandis* (teak) . . .	South Puri, (B. & O.) .	90	85	80	80	100	110	105	90
124	*Tectona grandis* (teak) . . .	Angul, (B. & O.) . .	105	90	95	95	80	100	110	120

TABLE No. 1.

Relative Suitability of woods grown in India—contd.

Serial No. 1	Species. 2	Locality. 3	Weight. 4	Strength as a beam. 5	Stiffness as a beam. 6	Suitability as a post. 7	Shock resisting ability. 8	Retention of shape. 9	Shear. 10	Hardness. 11
	Tectona grandis (teak)	Burma and Malabar	100	100	100	100	100	100	100	100
125	*Tectona grandis* (teak) . . .	Hoshangabad, (C. P.) .	90	85	90	85	105	100	110	85
126	*Tectona grandis* (teak) . . .	Central Puri, (B. & O.) .	95	90	90	90	115	105	115	105
127	*Terminalia arjuna (arjun)* . .	Kolhan, (B. & O.) .	115	75	70	70	135	65	140	135
128	*Terminalia belerica (bahera)* . .	Insein, (Burma) . .	115	100	115	105	110	65	120	115
129	*Terminalia bialata (white chuglam)*	South Andaman . .	100	90	105	95	105	65	100	100
130	*Terminalia chebula* (myrobalan) .	Insein, (Burma) . .	135	100	105	105	125	55	130	135
131	*Terminalia manii (black chuglam)* .	South Andaman . .	120	95	105	105	115	60	135	145
132	*Terminalia paniculata (kindal)* .	Nilambur, (Madras) .	115	100	110	105	105	60	110	125
133	*Terminalia paniculata (kindal)* .	East Kanara, (Bombay)	110	85	100	85	90	65	105	110
134	*Terminalia procera (white bombway)*	North Andaman . .	90	75	85	75	90	75	100	90
135	*Terminalia pyrifolia (lein)* . .	Pyinmana, (Burma) .	110	95	105	100	110	60	115	100
136	*Terminalia tomentosa* (laurel) .	Ramnagar, (U. P.) .	125	105	110	95	130	65	115	150
137	*Terminalia tomentosa* (laurel) .	Malabar, (Madras) .	130	85	90	85	105	60	125	165
138	*Vateria indica (vellapiney)* . .	North Mangalore, (Madras).	85	75	100	85	65	50	80	60
139	*Xylia dolabriformis (pyinkado)* .	Tharrawaddy, (Burma) .	135	125	130	135	150	70	155	175
140	*Xylia xylocarpa (irul)* . . .	North Kanara, (Bombay)	125	100	105	105	90	65	155	195

4. STICK DIAGRAMS OF TIMBER SUITABILITIES.

Long lists of tests data are rarely studied by the average reader even when expressed in the simplest form possible. Graphical representations of variable quantities are more readily grasped in such cases. A board was, therefore, prepared on which the suitability figures for various species of timber were indicated by small sticks of the species concerned proportional in length to the quality represented. This board has proved to be very popular as it affords a means of visualizing the relative merits of different species. It has already been copied for use in Museums. It has, therefore, been decided to present in this report timber suitability figures in the form of the popular "stick" diagrams.

In the following diagrams the lengths of the "sticks" are proportional to the suitability figures which are also written on them. A dotted line across the "sticks" shows the value for teak taken in every case as 100.

The suitability diagrams for *Artocarpus chaplasha* and *Casuarina equisetifolia,* because the figures have been derived from tests of green material only, are cross-hatched in a different way to distinguish them from other species for which the values are based on more complete data.

The values for shock resisting ability for *Anogeissus latifolia* from Madras and for *Dipterocarpus tuberculatus* from Burma are not given in the diagrams as data are not yet available.

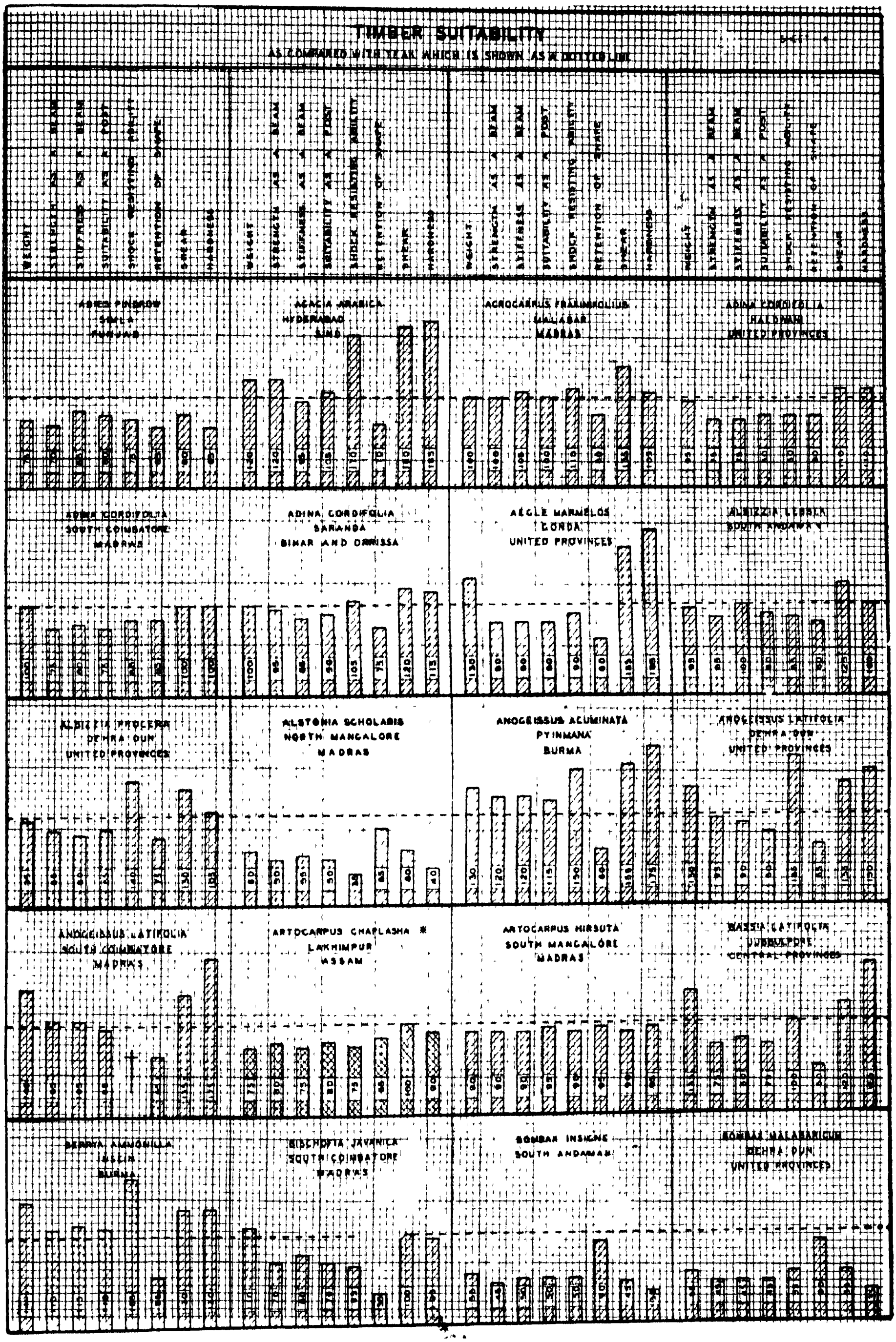

FIG 1

† Data not yet available

* Based on tests of Green material only

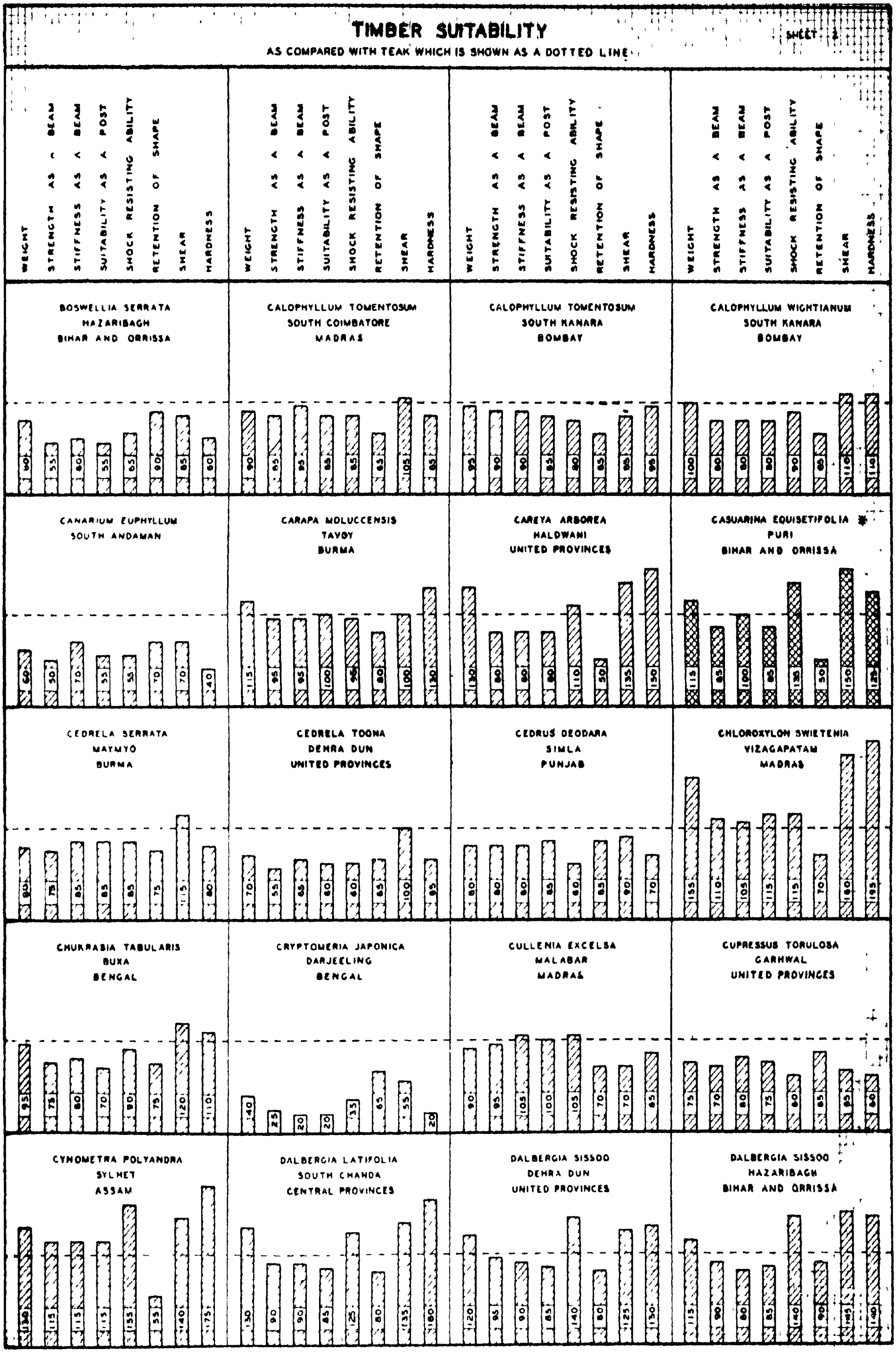

FIG 2

* Based on tests of Green material only

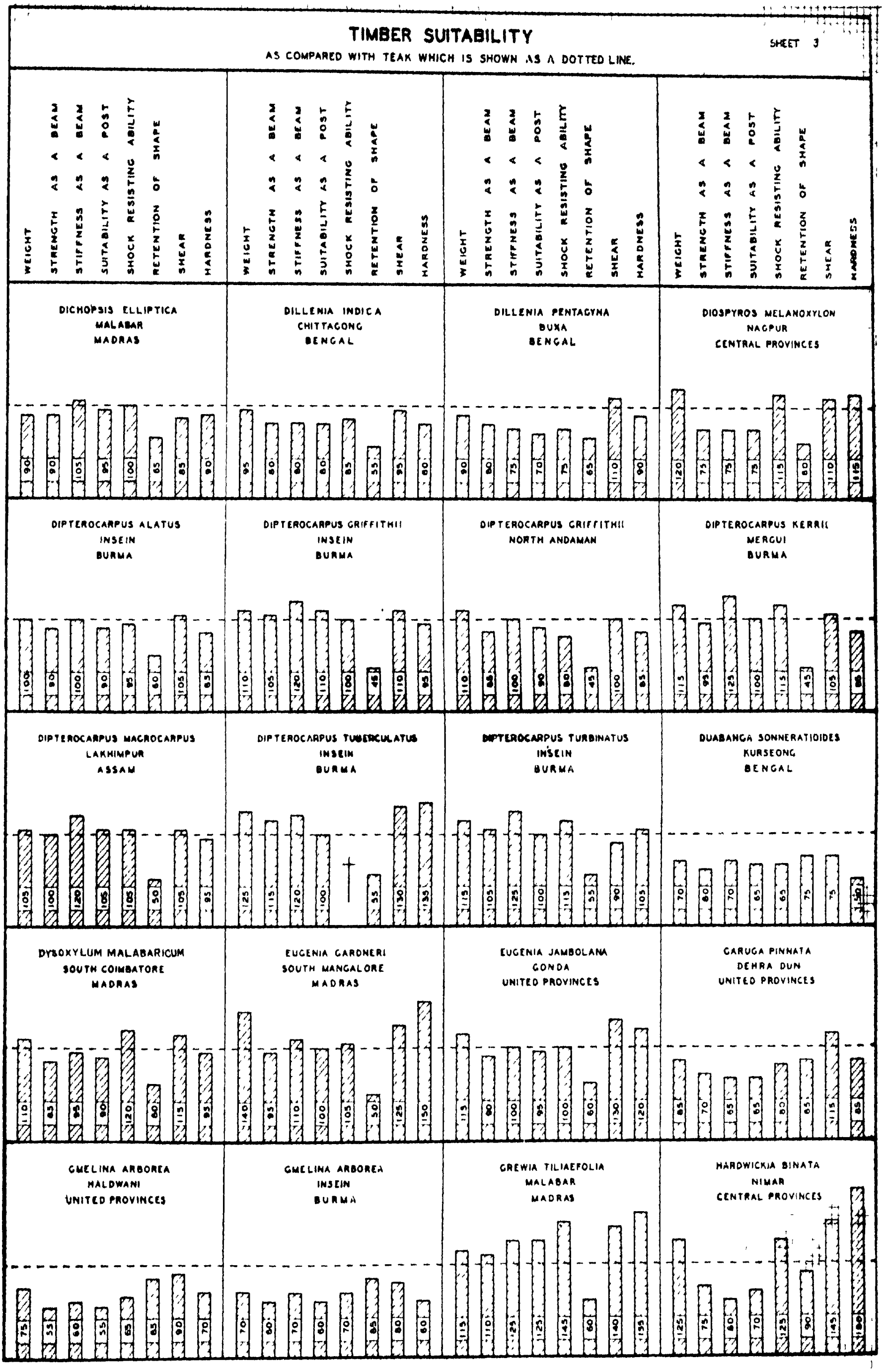

FIG 3

† Data not yet available

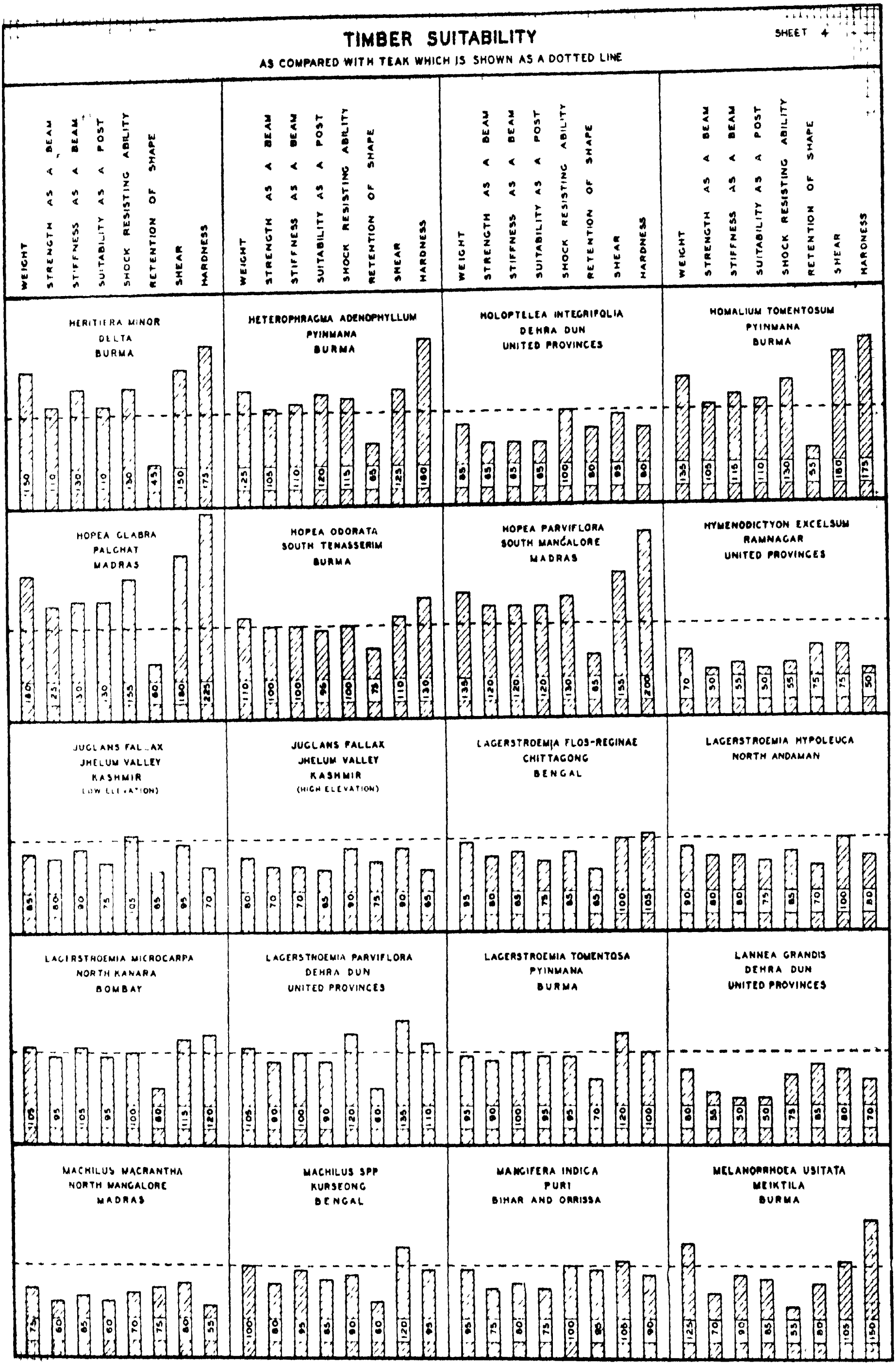
TIMBER SUITABILITY
AS COMPARED WITH TEAK WHICH IS SHOWN AS A DOTTED LINE
SHEET 4
WEIGHT
STRENGTH AS A BEAM
STIFFNESS AS A BEAM
SUITABILITY AS A POST
SHOCK RESISTING ABILITY
RETENTION OF SHAPE
SHEAR
HARDNESS
HERITIERA MINOR
DELTA
BURMA
150 110 130 110 130 45 150 175
HETEROPHRAGMA ADENOPHYLLUM
PYINMANA
BURMA
125 105 110 120 115 65 125 180
HOLOPTELEA INTEGRIFOLIA
DEHRA DUN
UNITED PROVINCES
85 65 65 65 100 80 95 80
HOMALIUM TOMENTOSUM
PYINMANA
BURMA
135 105 115 110 130 55 160 175
HOPEA GLABRA
PALGHAT
MADRAS
160 125 130 130 155 60 180 225
HOPEA ODORATA
SOUTH TENASSERIM
BURMA
110 100 100 95 100 75 110 130
HOPEA PARVIFLORA
SOUTH MANGALORE
MADRAS
135 120 120 120 130 85 155 200
HYMENODICTYON EXCELSUM
RAMNAGAR
UNITED PROVINCES
70 50 55 50 55 75 75 50
JUGLANS FALLAX
JHELUM VALLEY
KASHMIR
(LOW ELEVATION)
85 80 90 75 105 65 95 70
JUGLANS FALLAX
JHELUM VALLEY
KASHMIR
(HIGH ELEVATION)
80 70 70 65 90 75 90 65
LAGERSTROEMIA FLOS-REGINAE
CHITTAGONG
BENGAL
95 80 85 75 85 65 100 105
LAGERSTROEMIA HYPOLEUCA
NORTH ANDAMAN
90 80 80 75 85 70 100 80
LAGERSTROEMIA MICROCARPA
NORTH KANARA
BOMBAY
105 95 105 95 100 80 115 120
LAGERSTROEMIA PARVIFLORA
DEHRA DUN
UNITED PROVINCES
105 90 100 90 120 80 135 110
LAGERSTROEMIA TOMENTOSA
PYINMANA
BURMA
95 90 100 95 95 70 120 100
LANNEA GRANDIS
DEHRA DUN
UNITED PROVINCES
80 55 50 50 75 85 80 70
MACHILUS MACRANTHA
NORTH MANGALORE
MADRAS
75 60 65 60 70 75 80 55
MACHILUS SPP
KURSEONG
BENGAL
100 80 95 85 90 60 120 95
MANGIFERA INDICA
PURI
BIHAR AND ORRISSA
95 75 80 75 100 95 105 90
MELANORRHOEA USITATA
MEIKTILA
BURMA
125 70 90 85 55 80 105 150

FIG. 4

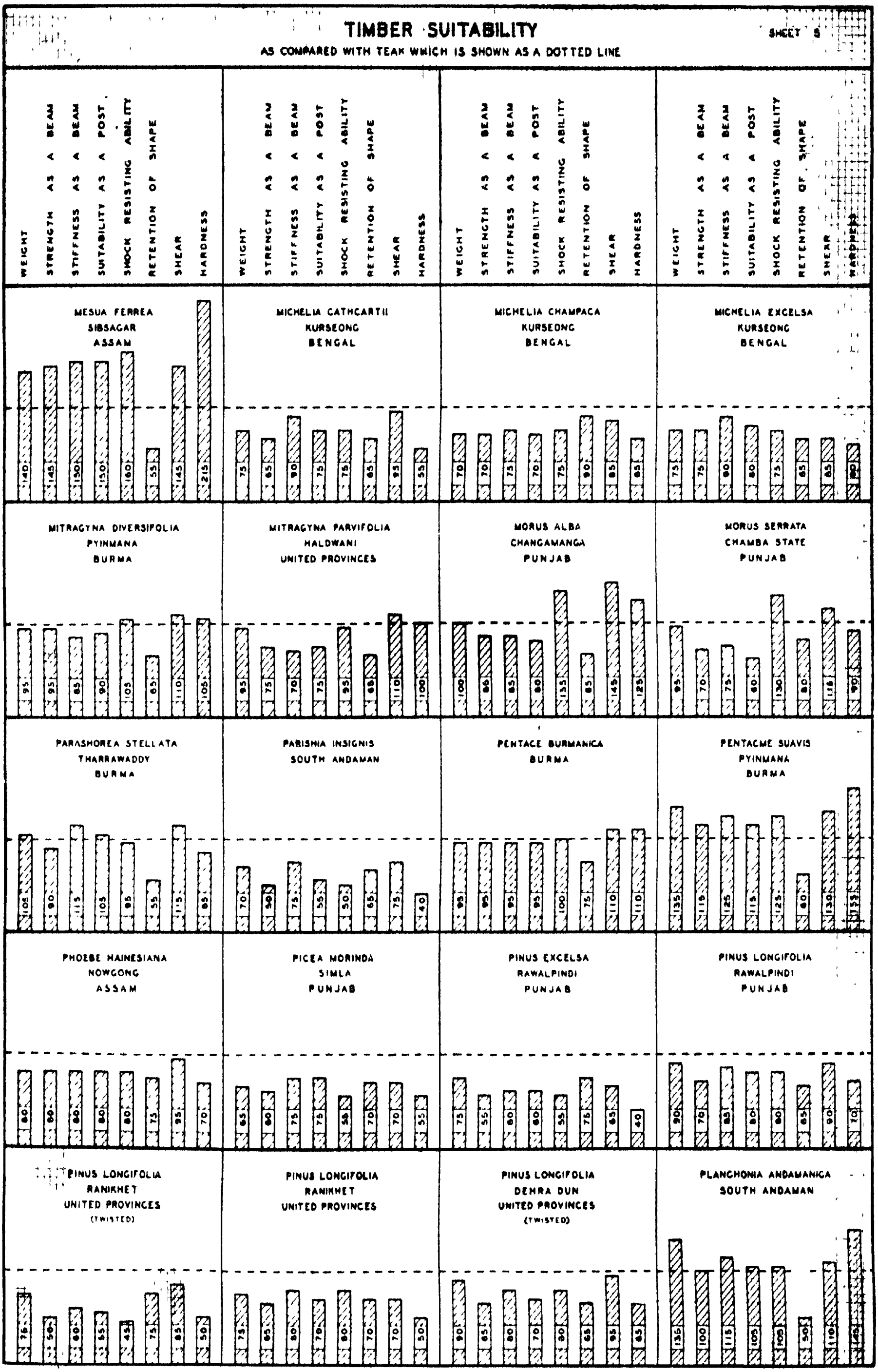
TIMBER SUITABILITY
AS COMPARED WITH TEAK WHICH IS SHOWN AS A DOTTED LINE
SHEET 5
WEIGHT
STRENGTH AS A BEAM
STIFFNESS AS A BEAM
SUITABILITY AS A POST
SHOCK RESISTING ABILITY
RETENTION OF SHAPE
SHEAR
HARDNESS
MESUA FERREA
SIBSAGAR
ASSAM
140 145 150 150 160 55 145 215
MICHELIA CATHCARTII
KURSEONG
BENGAL
75 65 90 75 75 65 95 55
MICHELIA CHAMPACA
KURSEONG
BENGAL
70 70 75 70 75 90 85 65
MICHELIA EXCELSA
KURSEONG
BENGAL
75 75 90 80 75 65 65 60
MITRAGYNA DIVERSIFOLIA
PYINMANA
BURMA
95 95 85 90 105 65 110 105
MITRAGYNA PARVIFOLIA
HALDWANI
UNITED PROVINCES
95 75 70 75 95 65 110 100
MORUS ALBA
CHANGAMANGA
PUNJAB
100 85 85 80 135 65 145 125
MORUS SERRATA
CHAMBA STATE
PUNJAB
95 70 75 60 130 80 116 90
PARASHOREA STELLATA
THARRAWADDY
BURMA
105 90 115 105 95 55 115 85
PARISHIA INSIGNIS
SOUTH ANDAMAN
70 50 75 55 50 65 75 40
PENTACE BURMANICA
BURMA
95 95 95 95 100 75 110 110
PENTACME SUAVIS
PYINMANA
BURMA
135 115 125 115 125 60 130 155
PHOEBE HAINESIANA
NOWGONG
ASSAM
80 80 80 80 80 75 95 70
PICEA MORINDA
SIMLA
PUNJAB
65 60 75 75 55 70 70 55
PINUS EXCELSA
RAWALPINDI
PUNJAB
75 55 60 60 55 75 65 40
PINUS LONGIFOLIA
RAWALPINDI
PUNJAB
90 70 85 80 80 65 90 70
PINUS LONGIFOLIA
RANIKHET
UNITED PROVINCES
(TWISTED)
75 50 60 55 45 75 85 50
PINUS LONGIFOLIA
RANIKHET
UNITED PROVINCES
75 65 80 70 80 70 70 50
PINUS LONGIFOLIA
DEHRA DUN
UNITED PROVINCES
(TWISTED)
90 65 80 70 80 65 95 65
PLANCHONIA ANDAMANICA
SOUTH ANDAMAN
135 100 115 105 105 50 110

FIG. 5.

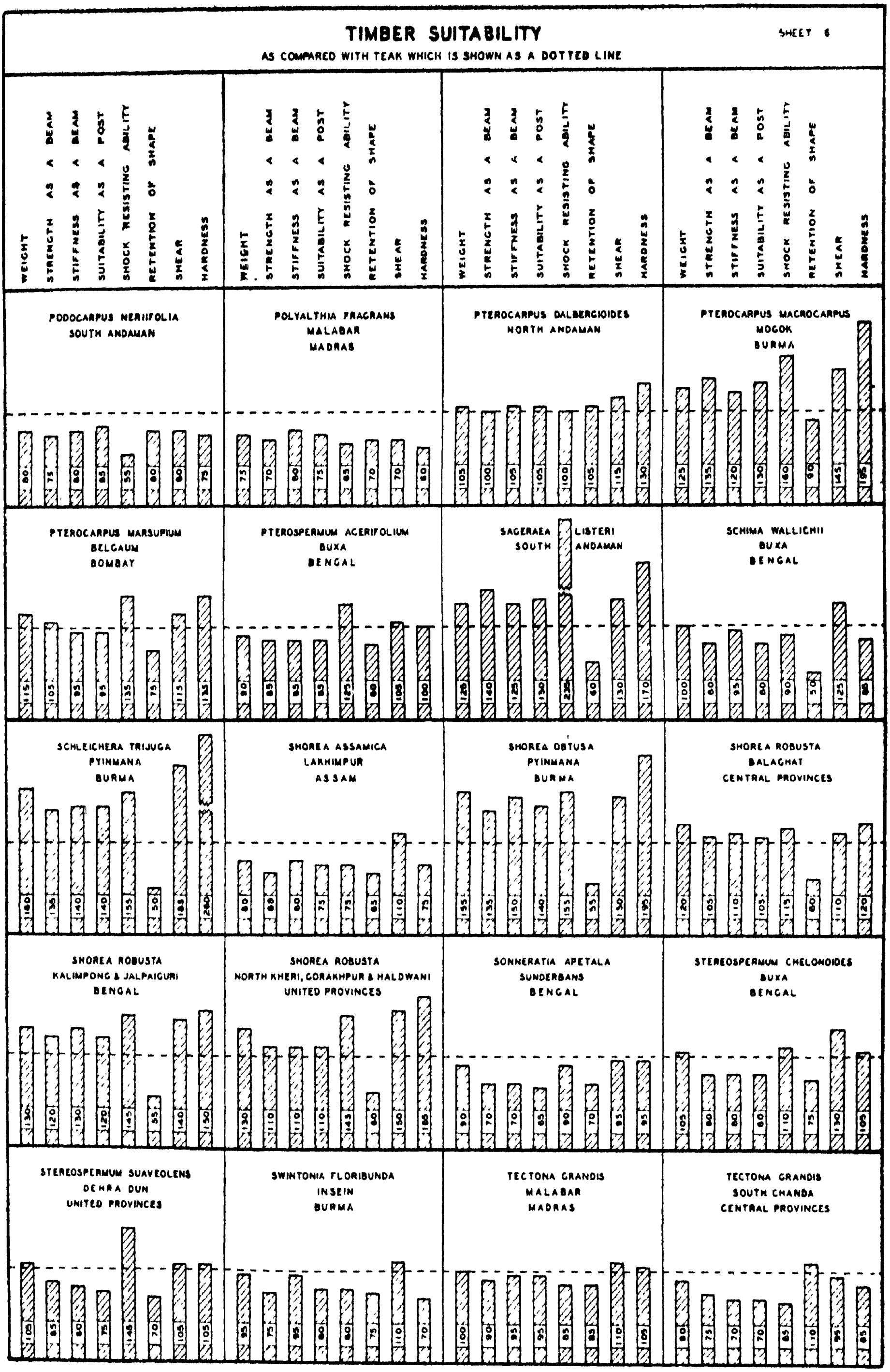
TIMBER SUITABILITY
SHEET 6
AS COMPARED WITH TEAK WHICH IS SHOWN AS A DOTTED LINE
WEIGHT
STRENGTH AS A BEAM
STIFFNESS AS A BEAM
SUITABILITY AS A POST
SHOCK RESISTING ABILITY
RETENTION OF SHAPE
SHEAR
HARDNESS
WEIGHT
STRENGTH AS A BEAM
STIFFNESS AS A BEAM
SUITABILITY AS A POST
SHOCK RESISTING ABILITY
RETENTION OF SHAPE
SHEAR
HARDNESS
WEIGHT
STRENGTH AS A BEAM
STIFFNESS AS A BEAM
SUITABILITY AS A POST
SHOCK RESISTING ABILITY
RETENTION OF SHAPE
SHEAR
HARDNESS
WEIGHT
STRENGTH AS A BEAM
STIFFNESS AS A BEAM
SUITABILITY AS A POST
SHOCK RESISTING ABILITY
RETENTION OF SHAPE
SHEAR
HARDNESS
PODOCARPUS NERIIFOLIA SOUTH ANDAMAN
80 75 80 85 55 80 80 75
POLYALTHIA FRAGRANS MALABAR MADRAS
75 70 80 75 65 70 70 60
PTEROCARPUS DALBERGIOIDES NORTH ANDAMAN
105 100 105 105 100 105 115 130
PTEROCARPUS MACROCARPUS MOGOK BURMA
125 135 120 130 160 90 145 195
PTEROCARPUS MARSUPIUM BELGAUM BOMBAY
115 105 95 95 135 75 115 135
PTEROSPERMUM ACERIFOLIUM BUXA BENGAL
90 85 85 85 125 80 105 100
SAGERAEA LISTERI SOUTH ANDAMAN
125 140 125 130 235 60 130 170
SCHIMA WALLICHII BUXA BENGAL
100 80 95 80 90 50 125 85
SCHLEICHERA TRIJUGA PYINMANA BURMA
160 135 140 140 155 50 185 280
SHOREA ASSAMICA LAKHIMPUR ASSAM
80 65 80 75 75 65 110 75
SHOREA OBTUSA PYINMANA BURMA
155 135 150 140 155 55 150 195
SHOREA ROBUSTA BALAGHAT CENTRAL PROVINCES
120 105 110 105 115 60 110 120
SHOREA ROBUSTA KALIMPONG & JALPAIGURI BENGAL
130 120 130 120 145 55 140 150
SHOREA ROBUSTA NORTH KHERI, GORAKHPUR & HALDWANI UNITED PROVINCES
130 110 110 110 145 60 150 185
SONNERATIA APETALA SUNDERBANS BENGAL
90 70 70 65 90 70 95 95
STEREOSPERMUM CHELONOIDES BUXA BENGAL
105 80 80 80 110 75 130 105
STEREOSPERMUM SUAVEOLENS DEHRA DUN UNITED PROVINCES
105 85 80 75 145 70 105 105
SWINTONIA FLORIBUNDA INSEIN BURMA
95 75 95 80 80 75 110 70
TECTONA GRANDIS MALABAR MADRAS
100 90 95 95 85 85 110 105
TECTONA GRANDIS SOUTH CHANDA CENTRAL PROVINCES
80 75 70 70 65 110 95 85

Fig. 6.

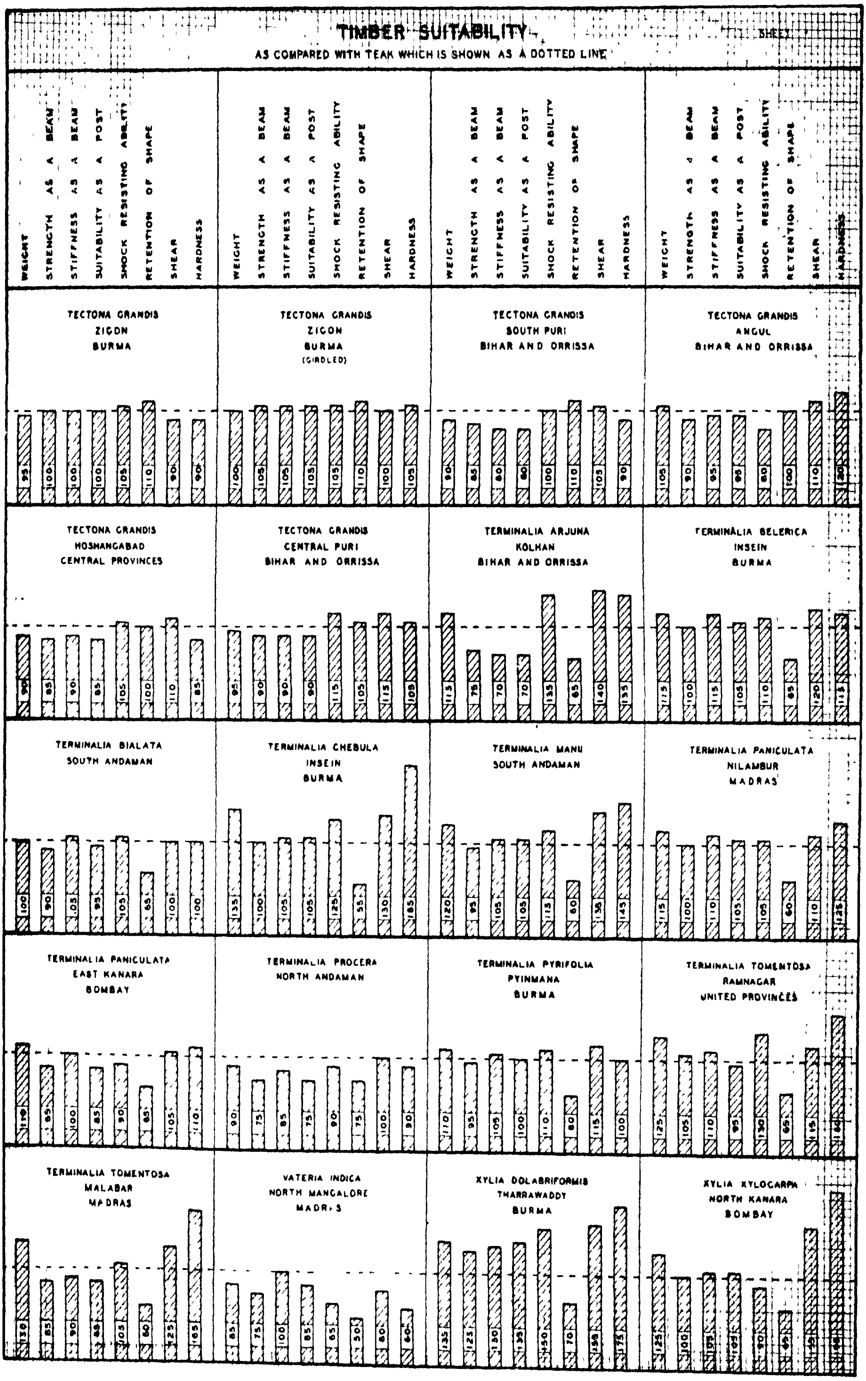
TIMBER SUITABILITY
SHEET
AS COMPARED WITH TEAK WHICH IS SHOWN AS A DOTTED LINE
WEIGHT
STRENGTH AS A BEAM
STIFFNESS AS A BEAM
SUITABILITY AS A POST
SHOCK RESISTING ABILITY
RETENTION OF SHAPE
SHEAR
HARDNESS
TECTONA GRANDIS ZIGON BURMA
95 100 100 100 105 110 90 90
TECTONA GRANDIS ZIGON BURMA (GIRDLED)
100 105 105 105 105 110 100 105
TECTONA GRANDIS SOUTH PURI BIHAR AND ORRISSA
90 85 80 80 100 110 105 90
TECTONA GRANDIS ANGUL BIHAR AND ORRISSA
105 90 95 95 80 100 110 120
TECTONA GRANDIS HOSHANGABAD CENTRAL PROVINCES
90 85 90 85 105 100 110 85
TECTONA GRANDIS CENTRAL PURI BIHAR AND ORRISSA
95 90 90 90 115 105 115 105
TERMINALIA ARJUNA KOLHAN BIHAR AND ORRISSA
115 75 70 70 135 65 140 135
TERMINALIA BELERICA INSEIN BURMA
115 100 115 105 110 85 120 115
TERMINALIA BIALATA SOUTH ANDAMAN
100 90 105 95 105 65 100 100
TERMINALIA CHEBULA INSEIN BURMA
135 100 105 105 125 55 130 185
TERMINALIA MANU SOUTH ANDAMAN
120 95 105 105 115 60 135 145
TERMINALIA PANICULATA NILAMBUR MADRAS
115 100 110 105 105 60 110 125
TERMINALIA PANICULATA EAST KANARA BOMBAY
110 85 100 85 90 65 105 110
TERMINALIA PROCERA NORTH ANDAMAN
90 75 85 75 90 75 100 90
TERMINALIA PYRIFOLIA PYINMANA BURMA
110 95 105 100 110 80 115 100
TERMINALIA TOMENTOSA RAMNAGAR UNITED PROVINCES
125 105 110 95 130 65 115 140
TERMINALIA TOMENTOSA MALABAR MADRAS
130 85 90 85 105 60 125 165
VATERIA INDICA NORTH MANGALORE MADRAS
85 75 100 85 65 50 80 60
XYLIA DOLABRIFORMIS THARRAWADDY BURMA
135 125 130 135 150 70 155 175
XYLIA XYLOCARPA NORTH KANARA BOMBAY
125 100 105 105 90 65

FIG. 7.

PART II.

1. METHOD OF TESTING.

Scope of the work.

* The study was undertaken in order to provide :—

(*a*) Reliable data upon which to base comparisons of the various species of wood with reference to their mechanical, physical and anatomical properties.

(*b*) Data to be used in conjunction with other data derived from tests of timbers in structural sizes for the establishment of correct strength functions and working stresses for various timbers.

(*c*) Data from which it will be possible to ascertain the relations, if any, which exist between the various mechanical properties and the fundamental physical and anatomical characteristics.

(*d*) Data upon which may be based analyses of the influence upon the mechanical, physical, and structural properties of timbers of such factors as—

  (1) Locality where grown,
  (2) Position of the timber in the tree radially—distance and direction from the pith,
  (3) Height of timber in the tree,
  (4) Change from green to air-dried and from green to kiln-dried conditions.

Tests employed in the study are as follows :—

Mechanical properties.

(1) Static Bending test.
(2) Impact Bending test.
(3) Compression Parallel to Grain test.
(4) Compression Perpendicular to Grain test.
(5) Hardness test—Radial, Tangential, and End grain.
(6) Shear Parallel to Grain test—Radial and Tangential.
(7) Tension Perpendicular to Grain test—Radial and Tangential.

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* Project 1, Mechanical, Physical and Structural Properties of Wood Grown in India, Tests on Small Clear Specimens, Scheme of Operation No. 1.

Physical properties.

1. Moisture content.
2. Specific gravity—specific gravities at the time of test and oven-dry are determined.
3. Shrinkage (Radial, Tangential, and Volumetric)—shrinkage values from green to oven-dry condition are determined.

Anatomical characteristics.

1. Rings per inch when discernible.
2. Percentage of sapwood when discernible.
3. Percentage of summerwood when discernible.

Selection of material.

Material required for testing a species is obtained from five straight-grained trees of merchantable size. The trees are selected in the forest by forest officers, felled in the proper season and sent to the laboratory at Dehra Dun accompanied by information as to altitude, aspect and conditions of growth.

Wood being a product of nature, its properties are influenced by a number of factors such as soil, climatic conditions, and environment, and the results of tests on wood from one locality may not be identical with those from the same species grown in another locality. For instance *Dipterocarpus griffithii* from Burma and *Terminalia tomentosa* from the United Provinces have been found to be stronger in most respects than the same species from the Andamans and Madras respectively. Species produced commercially in more than one province are collected and tested separately from each province concerned. The average of the results obtained from all such tests should, except in abnormal cases, be taken as representative of the strength of the species.

Allotment of logs.

As soon as the logs are received at the laboratory they are put into a log pond to await their turn for test. When a consignment is taken in hand, one of the logs is divided into two bolts each four feet long which are then cut into 2¼″ × 2¼″ sticks. The sticks are matched together and half of them are tested in the green condition while the other half are stacked and tested after air-drying. Material for kiln-dry tests is obtained in a similar way from another log, half the sticks in this case being sent to the Seasoning Section for kiln-drying. The remaining three logs are tested in the green condition. In the case of trees of small diameter, ten logs are tested instead of five, to give a representative average value.

Small clear specimens.

Wood is not a homogeneous material and is subject to defects such as shakes, knots, cross grain and borer holes. In order to eliminate the influence of these defects from the strength functions obtained, small clear specimens are chosen for test. The bolts are cut parallel to the axis of growth so as to avoid cross grain, and sticks finished to a dimension of 2″ × 2″ × 48″ are obtained. Test specimens of the required lengths and free from defects are cut from these sticks. It will, therefore, be seen that the test specimens are of uniform cross section of 2″ × 2″ and are free from natural defects as far as possible.

Influence of defects upon large timbers.

Timbers of large size, as used in building construction, generally contain some defects. Tests are, therefore, made on large specimens in order to determine the extent to which the strength is reduced by different kinds of defects. These results are useful in the preparation of grading rules and working stress tables for structural timbers. Tentative grading rules have already been published,* and working stress tables for structural sizes have been prepared from the values derived by testing small clear specimens in the green condition, which are adjusted by the application of safety factors found suitable in engineering practice.†

Tests on green timber.

In Table 3, results of tests on green material are given for 140 consignments of Indian timber. In this report, the term " green timber " means wood containing moisture in excess of that necessary to wet it to the fibre saturation point. Without undertaking a discussion of the significance of the fibre saturation point in timber it may be mentioned that, while the strength of wood varies with changes of dryness below that point, it undergoes no appreciable changes with different moisture contents above the fibre saturation point. Some trees contain large quantities of water while others hold comparatively smaller amounts depending in part upon the structure and density of the wood. All growing trees, however, have moisture contents well above the fibre staturation point, and consequently the strength functions in the green condition are not affected by differences in this respect. In Project No. 1, results from tests on green material afford a better basis of comparison than those from tests on air-dry material because, as indicated above, they are not influenced by differences of moisture content. Moreover, they are not affected by seasoning defects and they are averaged from a greater number of tests than are the values derived by testing seasoned specimens. The latter values are, however, necessary, because all species do not increase in strength to the same extent with seasoning.

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* The Indian Forest Records, Vol. XII, Part III, Second Interim Report on the Work under Project No. 1 by the Section of Timber Testing including the results of the Mechanical and Physical Tests on certain of the commoner Indian Timbers up to end of 1924.

† Printed in Report on Project 2 (Indian Forest Record, Vol. XVII, Part VII).

Results of tests on air-dry timber.

When wood is seasoned no appreciable change is produced in its dimensions or its strength until its moisture has been reduced to the fibre saturation point. Beyond this point, however, the wood shrinks and its strength functions undergo rapid changes, mostly incremental, with further decrease in moisture. The sticks from bolts marked for air-drying are stacked under cover for seasoning, and the tests are made after the moisture content has been reduced to about 12 per cent. The improvement in strength due to air-drying is then expressed as a percentage of the corresponding values obtained with green material from the same bolt. The result shown in italics in Table 3 are computed by multiplying the average values for the green material of the whole consignment by the respective improvement factors thus obtained.

Teak, the standard of comparison.

Teak has been selected as the standard for use as a basis of comparison. Consignments of teak were first obtained from different provinces and tested in the laboratory. Teak from Burma and teak from Malabar, although coming from localities about 1,500 miles apart were found to correspond very closely in their strength properties. Three consignments each of 5 trees, one from Burma (ungirdled teak), one from Burma (girdled teak), and the third from Malabar (ungirdled teak), were, therefore, averaged together and the values obtained from both green and air-dry tests were taken as the datum for comparing all species.

Detailed information concerning the procedure employed in Timber Testing at the Dehra Dun laboratory is given in "Project No. 1, Mechanical, Physical, and Structural Properties of Wood Grown in India, Tests on Small Clear Specimens, Scheme of Operation No. 1."

2. EXPLANATION OF STRENGTH TABLE No. 3.

The results of mechanical and physical tests on small clear specimens of 140 consignments of Indian timber are given in Table No. 3 both in the green and in the air-dry condition. The results of green tests are shown in roman and the results of air-dry tests are shown in italics.

In the first column the serial number is given.

Names of species.

In the second column will be found the names of the species together with the trade names or the names commonly used in the localities from which material was obtained for tests. The same species is often known by different names in different parts of India. In order to reduce the resulting confusion, the Forest Department has undertaken to standardize common names for some of the more important species. These standardized common names are known as " trade names " and are given in Table No. 2. They are recommended for use not only in India but in foreign markets also.* The trade name is in many cases the common name by which a species is known in the provinces where it is abundant. Examples of this are *kokko* and *padauk* which are the common names in the Andamans for *Albizzia lebbek* Benth., and *Pterocarpus dalbergioides* Roxb., respectively. The same common name, or even the same trade name, is sometimes applied to several species, as, for instance, *kanyin* or *gurjun*. The botanical nomenclature provides, therefore, the most reliable system of separating the different species and is universally used in scientific work. The species in the table are arranged in the alphabetical order of their botanical names, which are followed by the important vernacular or trade names.

Locality.

In the third column is listed the locality, *i.e.*, the name of the forest division and province from which the trees were obtained for test. The wood of different species is obtained for tests, in the first instance, from localities where it is abundant.

As already mentioned, the properties of one species may vary in different surroundings. It is proposed, therefore, to test each species from all localities where it is available in commercial sizes and quantities, so as to obtain a comprehensive average for the whole species. In some cases, however, where there is an abnormal difference in the properties of the timber grown in different localities, it becomes necessary to use different strength values for the same species according to its place of growth.

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* See Forest Bulletin No. 71 of 1929, Economy Series.

In Table No. 3 the values for different localities are given separately.

Number of trees.

The number of trees tested is shown in the fourth column. Five trees are usually taken for testing from each locality.* In cases where less than five trees have been tested, the results are tentative and may be subject to slight modification as more data become available.

Seasoning.

The condition of seasoning is indicated in the fifth column. Material tested green is marked 'G' and that tested air-dry marked 'A.D.' The air-dry specimens are tested as nearly as possible at 12 per cent moisture content, and the results are shown in italics in the table. As already stated, the values for green material are the more reliable for the comparison of species, and are also the appropriate values to use in the derivation of safe working stresses. They are free from the indefinite factor of seasoning stresses, and the danger of subsequent wetting of some structural parts. Even timber which is not exposed to the weather absorbs considerable moisture in the monsoon.

Rings per inch.

The sixth column records the average number of growth rings per inch measured along a radial line on the cross section of the wood. Seasonal growth rings, when visible, usually appear as dark bands or concentric lines caused by temporary retardation or complete cessation of meristematic activity. One ring is normally added every growing season, and the number of rings per inch is an inverse measure of the rate of growth, which may be as fast as 1 or 1½ rings per inch or as slow as 40 to 50 rings per inch, depending upon the circumstances under which the growth took place. The strength is sometimes influenced to a certain extent by the rate of growth. In conifers, excessively fast growth tends to produce weak wood, while in ring-porous woods of the broad-leaved species the faster growth, within limits, yields stronger wood. Abnormally fast or slow growth is usually a source of weakness in either case.

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* As laid down in Project 1, Mechanical, Physical and Structural Properties of Wood Grown in India, Scheme of Operation No. 1.

A growth rate of about 6 to 12 rings per inch in the case of teak appears to be favourable for the production of good-quality wood.

In the case of diffuse porous woods of the broad-leaved species it is often impossible to distinguish any seasonal growth rings. It is probable that conditions which affect the rate of growth of these trees also have an influence on the quality of the wood produced, but on account of the want of a visual method of determining the growth rate the number of rings per inch for such species is not recorded.

Percentage of summer wood.

By summer wood is meant the dark-coloured portion of the growth ring which is composed of thick-walled, strong elements. Consequently the greater the percentage of summer wood in the cross section of a piece the greater its strength.

When the spring wood and summer wood, or, more appropriately, the early wood and late wood, can be distinguished, the proportion of late wood gives some indication of the relative strength of the specimen. In coniferous species the amount of late wood in each growth ring appears to be less variable than the amount of early wood, resulting in an excess of the latter in wood which has grown very rapidly. Hence conifers which have grown moderately slowly, having a smaller proportion of thin-walled conducting tracheids, are stronger than those of excessively fast growth. In the case of the ring-porous species of the dicotyledons, on the other hand, variations in the width of the ring occur to a larger extent in the late wood portion, with the result that the faster grown ring-porous woods have a larger percentage of the thick-walled summer wood cells, and are stronger, within limits, than the wood of slower growth. In the diffuse-porous woods the structure is more uniform, and it is impossible to distinguish by visual examination between spring wood and summer wood. The majority of Indian woods are diffuse-porous and an estimation of summer wood in most cases is not possible.

Specific gravity.

The 'specific gravity' of the wood is given in columns 7 and 8. These values are obtained by dividing the weight of a specimen in grammes by its volume in cubic centimeters. What is found, therefore, is actually the density of the wood, but the term 'specific gravity' has become so well established in research relating to timber that it has been retained. These values furnish a reliable guide to the relative weights of the different species.

In timber research, the term 'specific gravity' requires to be qualified by a statement of the conditions under which the determination was made, because the volume of the wood is variable. As wood begins to shrink in seasoning the volume diminishes, and the final volume may, moreover, be affected by the initial conditions of drying. For reliable comparison of the different species it is necessary, therefore, that the functions should be derived from quantities that are constant. Such quantities are the weight of the oven-dry wood and its volume in the green condition. The specific gravity values recorded in column 7 refer to the volume of the wood at the time of test, green or air-dry as the case may be, and the weight of the oven-dry wood. They are determined by accurate measurement and weighment of all test specimens which have the form of right prisms. The weight data thus obtained include the moisture content of the specimens, for which they must be corrected after the moisture determinations have been made. The specific gravity at time of test is then calculated from the volume and the corrected weight.

The values presented in column 8, specific gravity oven-dry, are based on both the volume and the weight of the specimens after oven-drying. In this case the volume is usually determined by finding the weight of water displaced by the specimen, though displacement of mercury is sometimes employed.

Moisture content.

The moisture content is expressed as the ratio of the weight of water contained in the wood to the weight of the dry wood, and is given in column 9. A small disc is cut from each specimen near the failure, weighed as soon as possible after test, and carefully dried at 98° ± 3°C. in a well ventilated electric oven, provided with thermostatic temperature control. After drying to constant weight the disc is again weighed while still warm. The difference between the first and the last weights is the weight lost by the wood in drying, and is expressed as a percentage of the weight of the dry wood. This loss, of course, includes any other material that is volatile at 100°C. as well as the water. In exact analyses such volatile constituents are extracted separately, but they are not found normally * to introduce any serious error in practical moisture determinations.

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* In species exceptionally rich in volatile contents such as deodar (*Cedrus deodara*, Loudon), results of ordinary moisture determinations on seasoned material may be appreciably influenced.

Weight.

Weight, like specific gravity, is an indefinite quantity unless qualified by a statement of the conditions under which it was determined, and the moisture content to which it applies. The weight of wood is also influenced by the presence of gums, resins, or infiltration products, as well as the density of the wood substance itself, and may vary, to a certain extent, in different parts of the same tree.

The values in column 10 are the average weights of material tested green or air-dry as the case may be.

In column 11, the weight of seasoned timber corrected to 12 per cent. moisture content is given. These figures afford a means of comparing the relative weights of seasoned timbers of the different species.

Shrinkage.

Moisture occurs in green wood in two ways—as free water contained in the cell cavities and intercellular spaces, and as water required for cell wall saturation. Loss of the free water from the voids in the wood does not, in general, affect the dimensions of the material. When all the free water has been removed but the cell walls are still fully saturated, the wood is said to have reached the fibre saturation point, in which condition it still contains from 25 to 30 per cent moisture. On further drying shrinkage begins and continues until the wood is completely oven-dried.

Shrinkage in length is very small and is generally neglected. Shrinkage in the lateral directions is very much greater and is of importance in the use of wood. In the radial direction it varies from about 1·1 per cent to 6 per cent and in the tangential direction from about 3·3 per cent to 16·8 per cent in the species which have been tested. The volumetric shrinkage is, of course, the resultant of the shrinkages in all the three dimensions. Radial, tangential and volumetric shrinkage are all determined independently from separate samples as laid down in Project 1. In all cases the observations are for total shrinkage, *i.e.*, from green to oven-dry condition, and are given in columns 12, 13 and 14 respectively.

Special shrinkage tests have been conducted at Dehra Dun to determine to what extent shrinkage determinations based on small specimens can be relied upon to indicate the shrinkage which may be expected in planks of commercial size. The data so far obtained as a result of upwards of 40,000 observations clearly show that the shrinkage determinations based on small laboratory specimens furnish a reliable indication of the actual shrinkage in commercial sizes.

Static bending.

This is a very important test. The method of testing and the data recorded are described in "Project No. 1, Mechanical, Physical, and Structural Properties of Wood Grown in India." Briefly, the test is carried out on specimens, 2″ × 2″ × 30″ long, with a central load acting over a 28″ span. The loading head descends at the rate of $\frac{1}{10}$″ per minute and deflections are read correct to $\frac{1}{400}$″ simultaneously with the load without stopping the machine. The observations are then plotted and a load-deflection curve obtained, from which the strength functions are calculated.

Fibre stress at elastic limit.

Up to the elastic limit, or limit of proportionality of stress and strain, the deflections are proportional to the loads which cause them and the load-deflection curve takes the form of a straight line. If a beam is loaded within the elastic limit for a short time the resulting deflection disappears with the removal of the load, and the beam regains its original shape. If, however, a wooden beam is loaded to produce a stress approximating to its elastic limit, its deflection will continue to increase for a long time. If the load is in excess of the load at elastic limit, even by a small amount, the beam is liable ultimately to break. The fibre stress at elastic limit is, therefore, an important value, and beams should never be sufficiently loaded to reach this limit.

Modulus of rupture.

The modulus of rupture, given in column 16, is the apparent fibre stress in the outermost fibres at maximum load and is calculated in the same way as the fibre stress at elastic limit. Although the assumptions on which the bending theory is based do not hold good beyond elastic limit, the modulus of rupture is a convenient and reliable function for comparing the strengths of different species, as it reduces the danger of personal error present in the determination of the elastic limit. The modulus of rupture is the value adopted in the derivation of the safe working stresses * for Indian timbers printed elsewhere.

Modulus of elasticity.

The modulus of elasticity is given in column 17 and is a measure of stiffness. Woods with a high modulus of elasticity deflect little under

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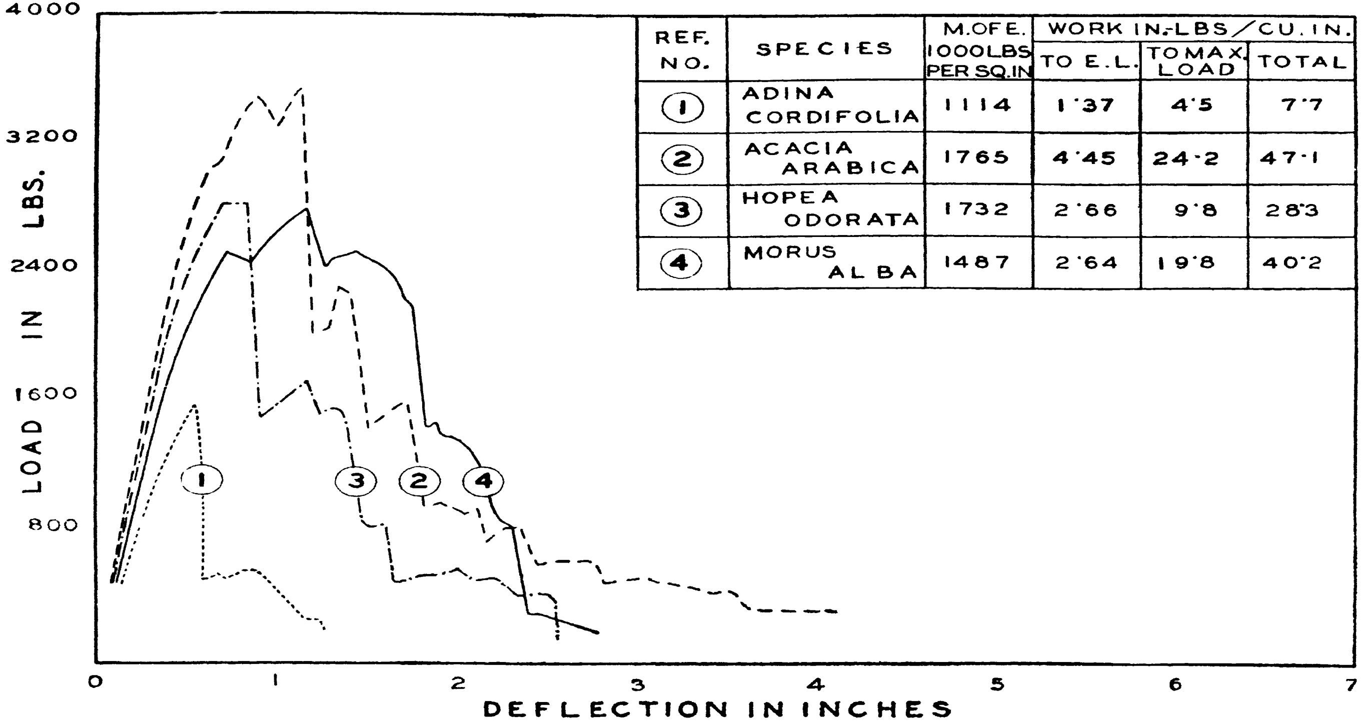
*Report on Work under Project No. 2, Strength Tests of Timbers in Structural Sizes with Test Results up to 1932.



REF. NO.	SPECIES	M. OF E. 1000 LBS PER SQ. IN	WORK IN.-LBS/CU. IN.		
			TO E. L.	TO MAX. LOAD	TOTAL
①	ADINA CORDIFOLIA	1114	1·37	4·5	7·7
②	ACACIA ARABICA	1765	4·45	24·2	47·1
③	HOPEA ODORATA	1732	2·66	9·8	28·3
④	MORUS ALBA	1487	2·64	19·8	40·2

FIG. 8

load and are rigid. This is exemplified in the extreme stiffness of *sundri* (*Heritiera minor*) which has a modulus of elasticity of 2,577,000 lbs. per sq. in., and the relatively greater flexibility of mulberry (*Morus alba*), for which the corresponding value is 1,622,000 lbs. per sq. in. The modulus of elasticity is the function which is used in computing the deflection of joists, beams, and other members subjected to bending.

Work.

Work is a measure of toughness and is proportional to the area included under the load-deflection curve. It is given in columns 18, 19, and 20, under the heading work to elastic limit, work to maximum load, and total work.

Work to elastic limit is a measure of the ability of a material to absorb shock without being stressed beyond its elastic limit.

A high value for work to maximum load (column 19), indicates a material that will absorb severe shocks before it begins actually to break. A considerable difference between the values for work to elastic limit and work to maximum load connotes a wide margin of safety, and a beam which is superior in this respect will seldom break suddenly, but will give warning of its failure by sagging considerably. The most suitable woods for the manufacture of articles requiring a combination of toughness and resilience are those which combine a moderately high value for modulus of elasticity with a satisfactory value for work to maximum load. If, in addition, a species has a high value for total work it may be expected to withstand considerable abuse. The possession of these qualities is evident in curve No. 4 of Figure No. 8, which is a typical load-deflection curve for Indian mulberry (*Morus alba*), which experience has shown to be a first-class wood for tennis racquets and hockey sticks.

The total work, shown in column 20, represents all the work absorbed by the specimen up to the completion of the test, which, in Project No. 1, is taken as the point at which the beam has either bent to a deflection of 6 inches or failed to support a load of 200 lbs. Readings beyond these limits do not materially increase the results.

Figure 8 illustrates typical load-deflection curves for four species of timber tested in the air-dry condition. Of these No. 1, *haldu* (*Adina cordifolia*), is the weakest, though in reality a moderately strong wood. Its relative weakness as compared with the other three species is shown by the positions of the highest points of the curves, while its comparative brittleness is indicated by the abrupt drop of curve No. 1 from its highest point and its relatively short extension beyond that point, No. 2, *babul* (*Acacia arabica*), and No. 3, *thingan* (*Hopea odorata*), have strength properties rather similar in nature, though differing in degree. The extra strength of the *babul* is indicated by the extra height of its curve. The curve of No. 4, mulberry (*Morus alba*), is different in nature from the other three. The strength of the wood is little inferior to that of *thingan*, but it is not so stiff and it is a great deal tougher. It is the possession of these two properties, indicated respectively by the greater slope of the initial portion of its curve, and by the relatively wide flat top of the curve and large area enclosed, that makes it such an excellent wood for sports goods.

Impact bending.

The specimens for the impact bending test are 2″ × 2″ × 30″ long. They are supported at the ends in special bearing blocks spaced 28″ centre to centre. A blow is delivered at mid-span by a freely falling 50-lb. weight, which is raised by an electro-magnet and automotically released at predetermined heights. Figure No. 9 illustrates the machine in operation.

The weight carries a stylus which presses against the surface of a vertical drum around which a sheet of paper is wound. The stylus thus registers on the paper the starting position, the height of drop, and the deflection of the beam under each impact, the drum being slowly rotated by hand during the test. The first drop is from a height of 2″, which is then increased by one inch for each succeeding drop until a height of 10″ is reached, after which 2-inch increases are employed until complete failure or 6″ deflection of the beam is obtained. Fig. 10 shows a typical impact drum record sheet for *Stereospermum suaveolens*.

The total height of drop, or the head, and the resulting deflection are obtained from the drum record sheets and the head is plotted against the square of the deflection. As within the elastic limit the square of the deflection varies directly with the height of drop producing it, the elastic limit is indicated on the graph by the point where the straight-line portion ends.

Fibre stress at elastic limit.

The fibre stress at elastic limit in impact bending, found in column 21, is the greatest stress to which a beam can be subjected by a blow and recover completely. With wood this stress is commonly about twice the corresponding stress found in static bending. Wooden beams, therefore, do not suffer as seriously from impact loads as do those of most other materials, and in designing timber beams no extra allowance need be made for suddenly applied live loads.

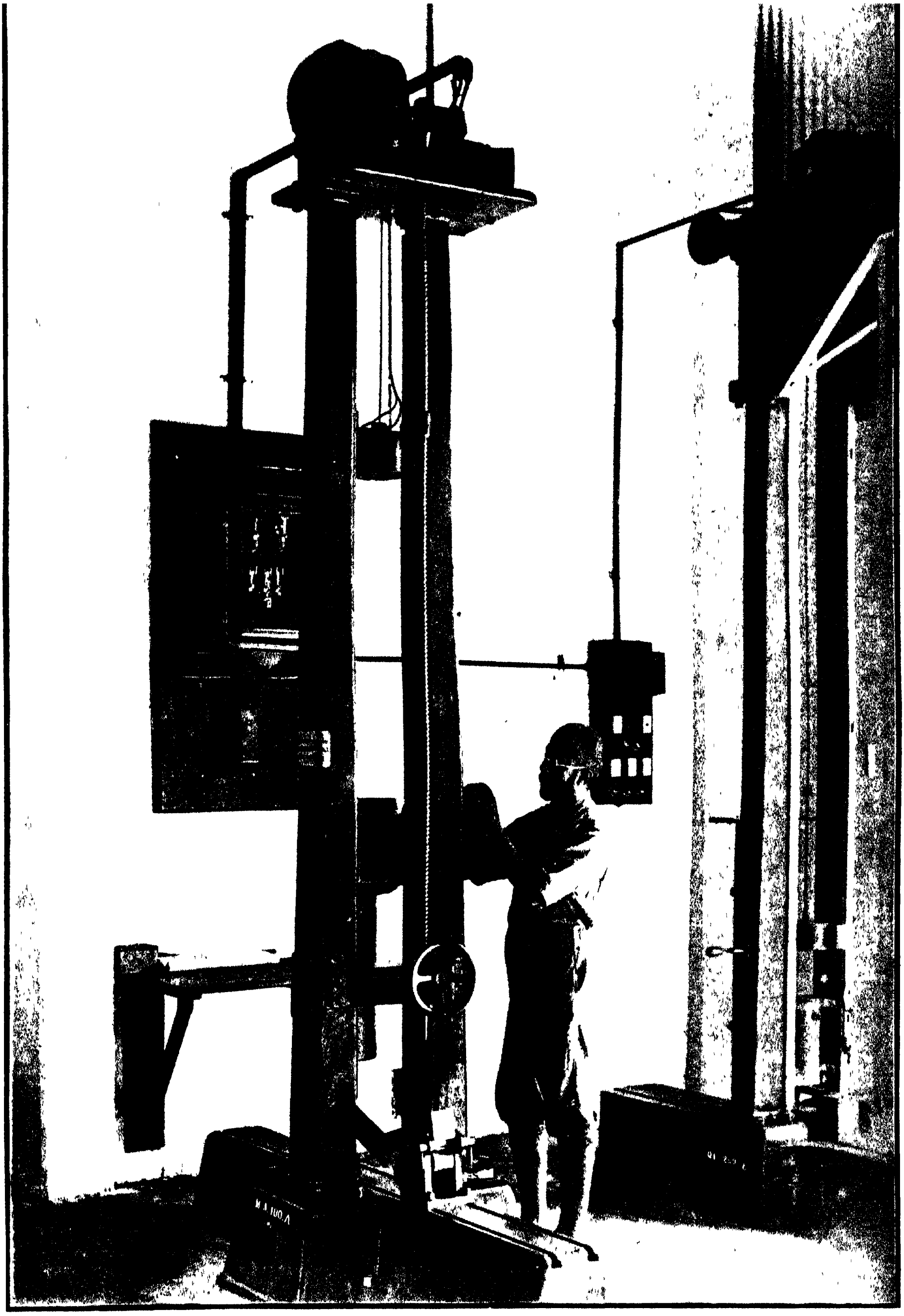


FIG 9

IMPACT TEST.

A blow is delivered at mid span by a freely falling 50 lbs. weight.

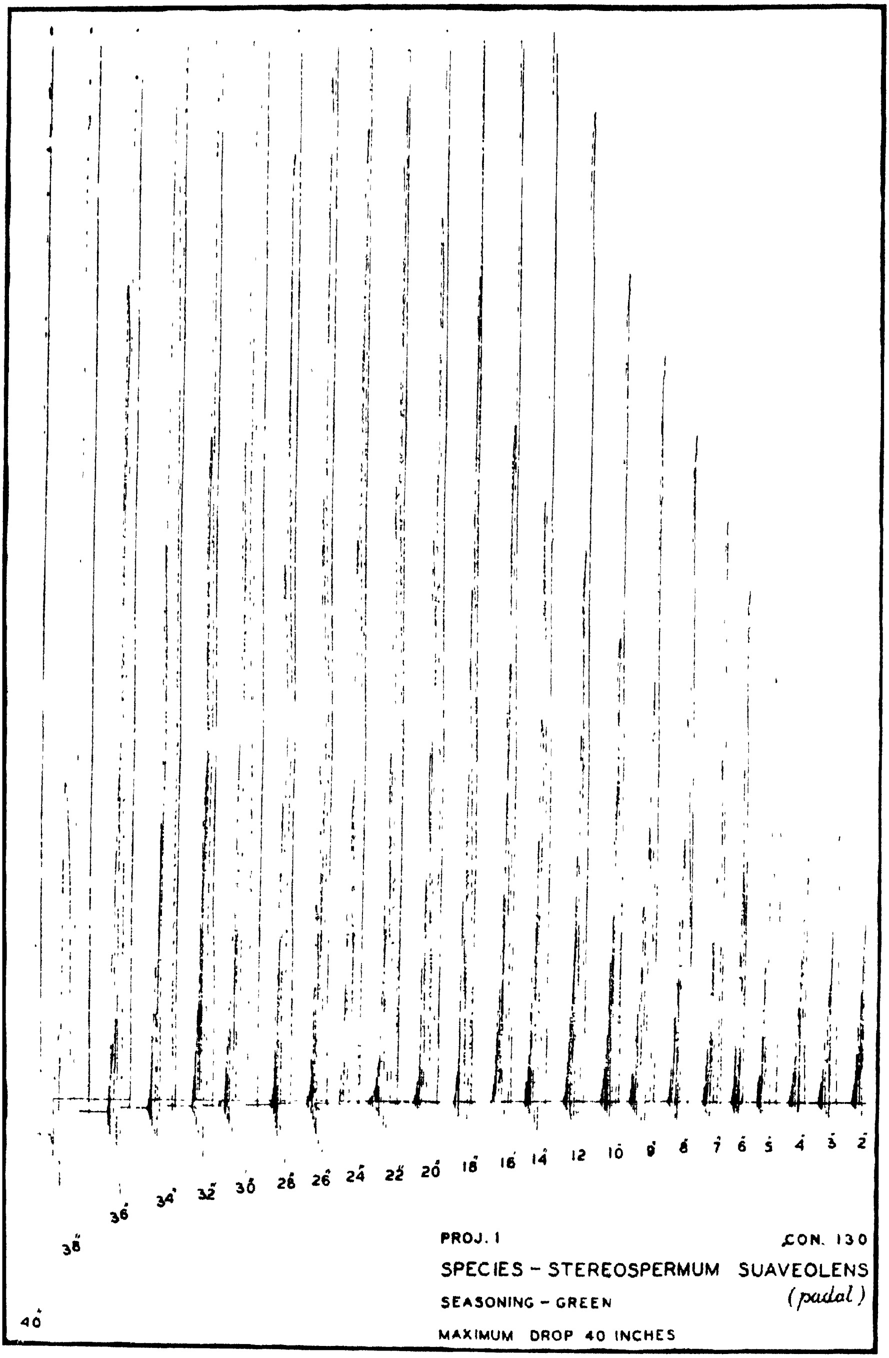


FIG. 10.

IMPACT TEST DRUM RECORD.

Maximum drop.

The value found in column 22 is the height, in inches, through which it was necessary to let the 50-lb. weight fall in order to break the specimens. It is an important function in determining the suitability of woods for use as hammer handles, spokes of wheels, sports goods, etc., and indicates the shock-resisting ability.

Modulus of elasticity.

The modulus of elasticity in impact bending is given in column 23, and, like fibre stress at elastic limit, is greater for impact than for static bending. This illustrates the superiority of wood in its power to resist and absorb live load shocks, and accounts in part for the high reputation it enjoys for use in aeroplane structure, sports goods, and railway sleepers.

It has been established from actual experiment that wooden beams continue deflecting for a long time under a steady dead load even if it be within the elastic limit. It is consequently good practice, in calculating the deflection of wooden beams, to use the live load *plus* double the dead load and employ the value of modulus of elasticity found from static bending tests.

Work to elastic limit.

Work to elastic limit in impact bending indicates the power of the wood to absorb shock without undergoing stress beyond its elastic limit

Compression parallel to grain.

The specimens used for this test measure 2″ × 2″ in cross section and 8″ along the grain. The ends are carefully prepared and the pressure applied through a hemispherical bearing block to avoid eccentric loading. Careful preparation and the shortness of the specimen prevent the danger of bending. The material is, therefore, stressed by a load which is acting axially along the grain.

Compressive stress at elastic limit.

This value, recorded in column 25, is a measure of the load which the wood can carry on its end grain without being stressed beyond its elastic limit. Although the maximum crushing stress is the value used in most engineering calculations, the compressive stress at elastic limit is employed in the selection of correct safety factors, and also in computing the index figure for suitability as a post or strut given in Table No. 1.

Maximum crushing stress.

Maximum crushing stress, (column 26), indicates the ability of the wood to sustain a slowly applied axial load on short columns without actual failure. This value is used, with the application of suitable safety factors, in designing columns. The computations may be based on crushing strength alone if the length of the column does not exceed about 10 times its least diameter.* In slender columns the stiffness becomes important and one of the standard column formulæ must be used in order to allow for the effect of possible eccentric load.

Modulus of elasticity.

The modulus of elasticity in compression parallel to grain in column 27, differs from that obtained in the bending test and is generally greater. The modulus determined in bending tests is influenced by the shearing properties of the wood. The fibrous nature of timber, moreover, causes it to offer very different resistance in different directions to the action of external forces.

Compression perpendicular to grain.

The specimens for the " compression perpendicular to grain " test are 2" × 2" in cross section and 6" in length. Load is applied through a 2" wide steel plate placed across the mid-length of the specimen on a radial surface. An area of about four square inches is subjected to direct compression in this way.

The only strength function studied in this case is the fibre stress at elastic limit, which represents the maximum stress which can be applied to the timber in this way without causing injury. This value is used in determining the necessary bearing area for beams, joists, and joints, and for comparing the suitability of woods for use as sleepers.

Hardness.

Hardness is tested by ascertaining the load required to imbed a steel ball of 0·444" diameter (1 square centimeter projected area †) in the wood to half its diameter. This test is applied to radial, tangential and end

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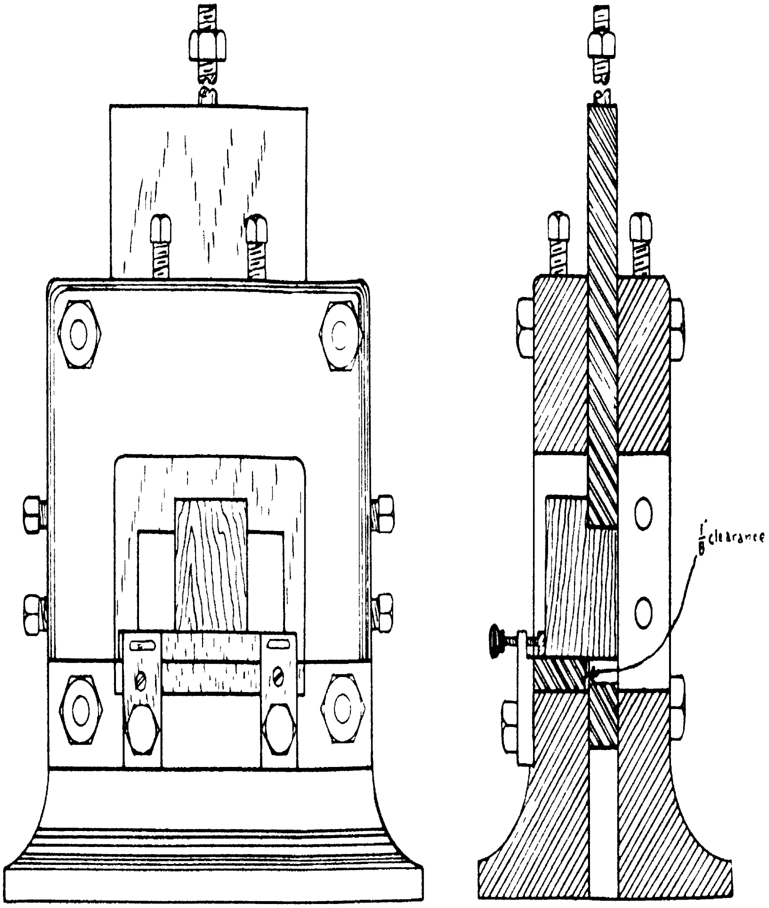
* Technical Bulletin No. 167, United States Department of Agriculture, Washington, D. C., U. S. A. " Tests of large Timber columns and presentation of the Forest Products Laboratory column Formula " by J. A. Newlin and J. M. Gahagan. (For sale by the Superintendent of Documents, Washington, D.C., U. S. A., Price 15 cents).

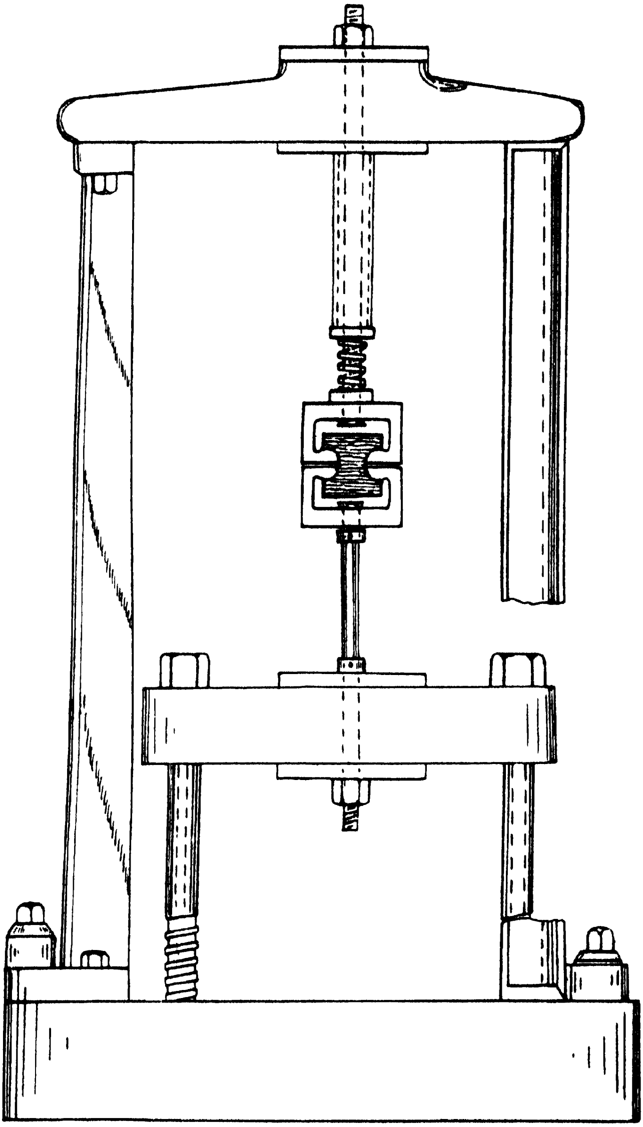
It is recommended that the formula presented in the above publication be used in the design of wooden structures until a formula devised from the analysis of tests at Dehra Dun on large timber columns of indigenous species becomes available.

† This is an adaptation of Prof. Janka's method.



SHEARING TEST TOOL.

FIG. 11.



APPARATUS FOR TENSION PERPENDICULAR TO GRAIN TEST.

FIG. 12.

surfaces and the results are tabulated in columns 29, 30 and 31 respectively. The values for hardness serve as an indication of the usefulness of a timber for railway sleepers, wooden floors, bearing blocks and in places where either abrasion or indentation is excessive.

Shear.

The specimen for shearing and the method of application of the load are shown in figure No. 11. The load is applied to a projection of the test specimen. As the steel loading plate descends, the projecting lip is sheared off from the rest of the block. The total load divided by the area over which it is distributed—about 4 square inches in this case—gives the shearing stress, and is presented in columns 32 and 33. Two sets of specimens are prepared, one presenting a radial surface and the other a tangential surface to the shearing force.

Tension perpendicular to grain.

The specimens for the "tension perpendicular to grain" test and the arrangement of the machine are shown in Fig. No. 12. In this case also the load is applied at right angles to the grain in radial and tangential planes, and the results are given in columns 34 and 35. These results are useful in estimating the strength of wood in resistance to the splitting action of bolts and other fastening acting across the grain.

3. HOW SUITABILITY FIGURES ARE CALCULATED

The reason for the adoption of suitability figures has been explained in an earlier part of this report. Briefly, the various strength functions which affect the usefulness of a timber for a particular purpose are combined to produce a single index figure indicating its relative value in (1) strength as a beam, (2) stiffness as a beam, (3) suitability as a post or strut, (4) shock resisting ability, (5) retention of shape, (6) shear and (7) hardness. The relative importance to be allotted to various properties is largely a matter of judgment, and difference of opinion may possibly exist as to the best procedure. The method was originally devised by the United States Forest Products Laboratory. Such modifications as seemed desirable have been made by the author and incorporated in this report.

This method of combining data involves :—(1) the determination of which strength functions should be combined in each suitability figure ; (2) the determination of adjusting factors to reduce the values of different functions to the same order of magnitude ; (3) the determination of weighting factors to give more or less relative importance to the different functions combined ; and (4) the determination of the best method for combining the results obtained from the tests of green and air-dry material to derive a single suitability figure.

The following is a list of the strength functions, adjusting factors, and weighting factors adopted in this report. The adjusting factors are calculated from the test results obtained with teak. The weighting factors are in many cases the same as those adopted by the United States Forest Products Laboratory, but in some cases modifications have been introduced as the result of experience with indigenous woods.

Functions Entering into the Calculation of Suitability Figures.

Suitability.	Strength functions.	ADJUSTING FACTORS.		Weighting factors.
		Green.	Air-dry 12 per cent Moist.	
Strength as a beam .	M. of R. in Static bending	1·00	1·00	2
	F. S. at E. L. in Static bending.	1·61	1·50	1
	F. S. at E. L. in Impact bending.	0·68	0·74	1
Stiffness as a beam .	M. of E. in Static bending	1·00	1·00	2
	M. of E. in Impact bending	0·77	0·76	1

Suitability.	Strength functions.	ADJUSTING FACTORS.		Weighting factors.
		Green.	Air-dry 12 per cent Moist.	
Suitability as a post or strut.	Max. Cr. Str. in Comp. parallel to grain.	1·00	1·00	1
	F. S. at E. L. in Comp. parallel to grain.	1·44	1·47	1
	M. of E. in Static bending.	3·51	4·53	1
Shock resisting ability	Work to Max. load in Static bending.	1·00	1·00	2
	Total work in Static bending.	0·34	0·43	1
	Height of drop in Impact bending.	0·266	0·428	1
Retention of shape .	Shrinkage— volumetric (Green to oven dry).	1·00	. .	2
	radial (Green to oven dry).	2·96	. .	1
	tangential (Green to oven dry).	1·62	. .	1
	Ratio of tangential : radial	3·72	. .	2
	Retention of shape $= \frac{1}{\text{shrinkage}} \times 100$.	. .	. .	. .
Shear . . .	Radial	1·00	1·00	1
	Tangential . . .	0·90	0·85	1
Hardness . .	F. S. at E. L. in comp. perpendicular to grain.	1·00	1·00	2
	Radial hardness . .	1·01	1·30	1
	Tangential hardness .	1·03	1·31	1
	End hardness . . .	1·15	1·37	1

Average test results from each consignment are used. Figures for green and air-dry material are first calculated separately and then combined, giving a weightage of 2 to the values based on green material.

Thus the final suitablity figure $= \frac{2G + AD}{3}$

Where G= suitability figure calculated from values of tests on specimens in the green condition.

AD= suitability figure calculated from values, corrected to 12 per cent moisture content, of tests on specimens in the air-dry condition.

Sample calculation.

The following example, based on the tests of axle-wood (*Anogeissus latifolia*) from the United Provinces, will illustrate the method of calculation. Test results for air-dry material are corrected to their equivalent values corresponding to a 12 per cent moisture content, by employing the following formulæ devised by the United States Forest Products Laboratory :—

(1) If the moisture content of air-dry material is under 12 per cent.

$$D_{12}=\frac{6(AD-G)}{18\text{-}m}+G$$

(2) If the moisture content of air-dry material is over 12 per cent.

$$D_{12}=\frac{10(AD-G)}{22\text{-}m}+G$$

Where D_{12} = the value of the function reduced to its equivalent for 12 per cent moisture content.

m = the moisture content at which air-dry tests were made.

Suitability Figures Based on Results of Tests in the Green Condition.

Required to find.	Green values.	Adjusting factors.	Weighting factors.	Suitability figures.
Strength as a beam.				
M. of R. in Static bending	11,445	× 1·00 ×	2	=22,890
F. S. at E. L. in Static bending	5,962	× 1·61 ×	1	= 9,599
F. S. at E. L. in Impact bending	17,946	× 0·68 ×	1	=12,202
			4)	44,692
				11,173
Stiffness as a beam.				
M. of E. in Static bending	1,501	× 1·00 ×	2	= 3,002
M. of E. in Impact bending	1,947	× 0·77 ×	1	= 1,499
			3)	4,501
				1,500
Suitability as a post or strut.				
Max. Cr. Str. in comp. parallel to grain	5,168	× 1·00 ×	1	= 5,168
C. S. at E. L. in comp. parallel to grain	2,679	× 1·44 ×	1	= 3,858
M. of E. in Static bending	1,501	× 3·51 ×	1	= 5,269
			3)	14,295
				4,765

Suitability Figures Based on Results of Tests in the Green Condition—contd.

Required to find.	Green values.	Adjusting factors.	Weighting factors.	Suitability figures.
Shock resisting ability.				
Work to Max. load in Static bending	16·5 ×	1·00 ×	2 =	33·00
Total work in Static bending	51·9 ×	0·34 ×	1 =	17·65
Height of drop in Impact bending	56·0 ×	0·266 ×	1 =	14·90
			4)	65·55
				16·4
Retention of shape.				
Shrinkage volumetric (green to oven dry)	12·2 ×	1·00 ×	2 =	24·40
Shrinkage radial (green to oven dry)	3·9 ×	2·96 ×	1 =	11·54
Shrinkage tangential (green to oven dry)	7·3 ×	1·62 ×	1 =	11·83
Shrinkage Ratio—tangential : radial	1·87 ×	3·72 ×	2 =	13·91
			6)	61·68
Shrinkage		....		10·3
Retention of shape $=\frac{1}{\text{shrinkage}}\times100=\frac{1}{10\cdot3}\times100$		....		9·7
Shear.				
Radial	1,378 ×	1·00 ×	1 =	1,378
Tangential	1,493 ×	0·90 ×	1 =	1,344
			2)	2,722
				1,361
Hardness.				
C. S. at E. L. in Comp. perp. to grain	1,176 ×	1·00 ×	2 =	2,352
Radial hardness	1,630 ×	1·01 ×	1 =	1,646
Tangential hardness	1,605 ×	1·03 ×	1 =	1,653
End hardness	1,670 ×	1·15 ×	1 =	1,921
			5)	7,572
				1,514

Suitability Figures Based on Results of Tests in the Air Dry Condition.

Required to find.	Air dry values.	Adjusting factors.	Weighting factors.	Suitability figures.
Strength as a beam.				
M. of R. in Static bending	13,749 ×	1·00 ×	2	=27,498
F. S. at E. L. in Static bending	6,305 ×	1·50 ×	1	= 9,458
F. S. at E. L. in Impact bending	21,737 ×	0·74 ×	1	=16,085
			4)	53,041
				13,260
Stiffness as a beam.				
M. of E. in Static bending	1,650 ×	1·00 ×	2	= 3,300
M. of E. in Impact bending	2,057 ×	0·76 ×	1	= 1,563
			3)	4,863
				1,621
Suitability as a post or strut,				
Max. Cr. Str. in comp. parallel to grain . .	6,047 ×	1·00 ×	1	= 6,047
F. S. at E. L. in comp. parallel to grain . .	3,497 ×	1·47 ×	1	= 5,141
M. of E. in Static bending	1,650 ×	4·53 ×	1	= 7,475
			3)	18,663
				6,221
Shock resisting ability.				
Work to max. load in Static bending . . .	13·9 ×	1·00 ×	2	= 27·80
Total work in Static bending	51·3 ×	0·43 ×	1	= 22·06
Height of drop in Impact bending	31·0 ×	0·428 ×	1	= 13·27
			4)	63·13
				15·8
Shear.				
Radial	1,753 ×	1·00 ×	1	= 1,753
Tangential	2,139 ×	0·85 ×	1	= 1,818
			2)	3,571
				1,786
Hardness.				
F. S. at E. L. in comp. perpendicular to grain .	1,947 ×	1·00 ×	2	= 3,894
Radial hardness	1,901 ×	1·30 ×	1	= 2,471
Tangential hardness	1,948 ×	1·31 ×	1	= 2,552
End hardness	2,203 ×	1·37 ×	1	= 3,018
			5)	11,935
				2,387

Final Suitability Figures (Green and Air-Dry combined).

Suitability.	$\frac{2G + AD}{3}$	Combined suitability figure.	Per cent of teak.
Strength as a beam	$\frac{22,346+13,260}{3}$	11,869	95
Stiffness as a beam	$\frac{3,000+1,621}{3}$	1,540	89
Suitability as a post or strut	$\frac{9,530+6,221}{3}$	5,250	78
Shock resisting ability	$\frac{32·8+15·8}{3}$	16·2	105
Retention of shape	based on green value only.	9·7	66
Shear	$\frac{2,722+1,786}{3}$	1,503	134
Hardness	$\frac{3,028+2,387}{3}$	1,805	150

The percentage figures thus found are rounded to the nearest five and given in Table No. 1.

4. EXPLANATION OF TERMS USED.

Air-Dry (*A. D.*).—See Seasoning.

Compression Parallel to Grain.—This is a test of the strength of the wood when subjected to a load acting axially along the grain of the wood. In the test the length of specimen is not more than four times the least cross sectional dimension and the load is applied slowly.

Compression Perpendicular to Grain.—This is a test of the load that the wood is able to carry when applied slowly across its grain. This test is of use in determining the allowable bearing pressures in the case of structural members, bearing blocks, rails on sleepers, etc.

Compressive Stress at Elastic Limit (*C. S. at E. L.*) *in Compression Parallel to Grain.*—This signifies the greatest load per square inch that the wood is able to carry on its end grain without passing the elastic limit.

Compressive Stress at Elastic Limit (*C. S. at E. L.*) *in Compression Perpendicular to Grain.*—This is the greatest load per square inch applied across the grain, which the wood is able to carry before the elastic limit is passed.

Elastic Limit (*E. L.*).—When a material is stressed it undergoes a strain, and up to a certain limit the increase in strain is proportional to the increase in stress. The greatest stress up to which this proportionality holds good is called the elastic limit. Beyond this point the strain of the material increases more rapidly than the stress. This property is also termed the "limit of proportionality of stress and strain."

End Hardness.—See Hardness.

End surface.—A plane section of wood at right angles to the grain is called the end surface.

Fibre Saturation Point.—Water is contained in wood in two ways *viz.*, (*a*) that absorbed by the cell walls and (*b*) that occupying the voids. If wood is dried *uniformly* the free water is evaporated first. A stage is ultimately reached at which all the free water has evaporated and only the water absorbed by the cell walls remains. This state is called the "fibre saturation point."

Fibre Stress.—This term is used to designate the stress in the outermost fibres of a loaded material.

Fibre Stress at Elastic Limit (*F. S. at E. L.*).—This is the greatest stress that the fibres can sustain without passing their elastic limit. In the case of wood F. S. at E. L. is different for different kinds of loading *e.g.*, in static and in impact bending.

Green (*G.*).—See Seasoning.

Hardness.—The hardness of wood is tested by finding the load which is necessary to indent the surface to a certain depth with a ball of given diameter. The hardness of wood is measured in three planes at right angles to each other, *viz.*:—

(1) end hardness, when the ball is forced into the end surface,
(2) radial hardness, when the ball is forced into the radial surface,
(3) tangential hardness, when the ball is forced into the tangential surface.

Height of Drop in Impact Bending.—This signifies the height through which it is necessary for a freely falling weight of 50 lbs. to drop on to the middle of a beam of 2″ × 2″ cross section and supported on a 28″ span, in order completely to fracture it.

Impact Bending.—Impact bending is the test of beams under loads applied as blows. The beams are supported at each end and subjected to the blows of a weight which falls on to the middle of the beam in a manner somewhat similar to the action of a pile driver.

Kiln Dry (K. D.).—See Seasoning.

Maximum Crushing Stress (Max. Cr. Str.) in Compression Parallel to Grain.—This signifies the load per square inch which applied to the end grain of the wood is just sufficient to break it.

Modulus of Elasticity (M. of E.)—This, also called "Young's Modulus," is the ratio of stress to strain within the elastic limit, and is a measure of stiffness.

Modulus of Rupture. (M. of R.)—This signifies the stress in the outer fibres of a beam at the instant of breaking, calculated on the assumption that the stress conditions of the beam are the same beyond as within the elastic limit. The assumption is incorrect but the results are consistent and useful for comparing the strengths of beams of different materials.

Moisture Content.—The moisture content of wood is usually expressed as the ratio of the weight of the water it contains to the weight of the oven dry wood.

Oven dry.—See Seasoning.

Radial hardness.—See Hardness.

Radial shear.—See Shearing.

Radial tension.—See Tension.

Radial surface.—A plane section of wood in the direction of the medullary rays is called the radial surface.

Seasoning.—Seasoning is the process of drying timber to fit it for use. The condition of dryness of wood is also designated as its "seasoning." The seasoning conditions mentioned in this report are:—(1) Green, (2) Air dry, (3) Kiln dry, and (4) Oven dry.

(1) *Green* (*G*).—Results tabulated under the heading "green" have been obtained from material tested as soon as possible after felling. All timber tested green contains moisture in excess of the fibre saturation point.

(2) *Air dry* (*A. D.*)—Values tabulated under this heading have been obtained by testing material which has been seasoned, as nearly as possible, to a moisture content of 12 per cent. Strictly speaking, "Air dry" signifies the condition of wood when it has reached a state of hygroscopic equilibrium with the atmosphere, and this condition varies with changes of climate and of season.

(3) *Kiln dry* (*K. D*).—This term is used to designate timber which has been subjected to accelerated and controlled seasoning in a kiln. For test purposes the moisture content of kiln seasoned wood is kept, as nearly as possible, at 12 per cent.

(4) *Oven dry.*—Specimens are said to be "oven dry" when they have been subjected to a controlled temperature of approximately 100° C. until they have ceased to lose weight.

Shearing :—

(1) *Shearing Parallel to Grain test.*—This is a test of the strength of the wood to resist a force, acting in the direction of the grain, which tends to cause one portion of the body to slip past the other. The specimens are tested in shear both on the radial and the tangential planes.

(2) *Radial Shear.*—Shear is said to be radial when the plane of failure coincides with the plane of the wood rays.

(3) *Tangential Shear.*—Shear is said to be tangential when the plane of failure is tangent to the seasonal growth rings.

Specific Gravity (*Sp. Gr.*)— The term specific gravity as used in timber testing means the ratio of the weight of the oven dry wood in a specimen to the weight of water equal to the volume of the specimen at the time that it was tested.

Static Bending.—This term is used to designate tests in strength as a beam, in which the load is applied slowly so that the conditions of test correspond closely to those of static loading.

Strain.—Strain is the deformation or change of shape or size produced in a material by the action of external forces.

Stress.—The force exerted by the material of the test specimen in resistance to deformation is called stress.

Tangential Hardness.—See Hardness.

Tangential Shear.—See Shearing.

Tangential Surface.—A plane section of wood in a direction tangential to the seasonal growth rings is called the tangential surface.

Tangential Tension.—See Tension.

Tension :—

Tension Perpendicular to Grain.—This is a test of the strength of wood in resistence to splitting when it is pulled apart in a direction at right angles to the grain. The test is conducted either :—

(1) to produce failure in a radial plane, (radial tension), or

(2) to produce failure in a tangential plane, (tangential tension).

Total Work.—See Work.

Work.—Work is the product of the force by the distance through which it acts, and is proportional to the area under the load deflection curve.

(1) ***Work to Elastic Limit.***—This is the amount of work per cubic inch absorbed by the specimen in stressing it to its elastic limit.

(2) ***Work to Maximum Load.***—This is the amount of work per cubic inch absorved by the specimen in stressing it to maximum load.

(3) ***Total Work.***—This is the amount of work per cubic inch absorbed by the specimen up to the completion of the test.

The following abbreviations for the names of different provinces, etc., are used in Table No. 2 :—

B. & O.	Bihar and Orissa.
C. P.	Central Provinces.
Syn.	Synonym.
U. P.	United Provinces.
Comp.	Compression.
Perp.	Perpendicular.

APPENDIX.

TABLE No. 2.

Index of the species of timber received for test, the progress and the provinces in which they are of economic importance.

Serial No.	Botanical Name (Authority).	Trade Name.	Locality from which received for testing.	Progress.	Localities where it is of economic importance.	Common names in those localities.
1	*Abies pindrow* (Spach) .	Himalayan silver fir.	Simla Division, Punjab .	All tests finished .	Punjab and United Provinces.	*rai*, *tos* (Punjab), *raga* (U. P.).
2	*Acacia arabica* (Willd) .	*babul* . . .	Hyderabad Division, Sind.	All tests finished	Punjab, United Provinces, Central Provinces, Bombay and Madras.	*kikar*, *babul* (Punjab), *babul* (U. P.), (C. P.) and (Bombay).
3	*Acrocarpus fraxinifolius* (Wight).	*mundani* . .	Chenat Nair Exploitation Division, Madras.	All tests finished	Madras	....
4	*Adina cordifolia* (Hook. f.).	*haldu* . .	Haldwani Division, U. P. .	All tests finished	United Provinces, Bihar and Orissa, Bombay, Madras and Burma.	*haldu*, *kurma*, (U. P.), *kurrum*, *kalando* (B. & O.), *heddi* (Bombay), *manjakadambai* (Madras) and *hnaw* (Burma).
5	*Adina cordifolia* (Hook. f.).	*haldu* . .	South Coimbatore Division, Madras.	All tests finished	United Provinces, Bihar and Orissa, Bombay, Madras and Burma.	*haldu*, *kurma* (U. P.) *kurrum*, *kalando* (B. & O.), *heddi* (Bombay), *manjakadambai* (Madras) and *hnaw* (Burma).
6	*Adina cordifolia* (Hook. f.).	*haldu* . .	Saranda Division, B. & O.	All tests finished	United Provinces, Bihar and Orissa, Bombay, Madras and Burma.	*haldu*, *kurma* (U. P.) *kurrum*, *kalando* (B. & O.), *heddi* (Bombay), *manjakadambai* (Madras) and *hnaw* (Burma).
7	*Ægle marmelos* (Correa)	..	Gonda Division, U. P. .	All tests finished	....	*bel*.
8	*Albizzia lebbek* (Benth) .	*kokko* . .	South Andaman . .	All tests finished	Punjab, Madras . .	*siris* (Punjab).
9	*Albizzia procera* (Benth).	*white siris* . .	Dehra Dun Division, U. P.	All tests finished	Burma	*thitpyu*, *sit* (Burma).
10	*Alnus nepalensis* (Don.)	Indian alder .	Darjeeling Division, Bengal.	Awaiting test .	Bengal	*utis* (Bengal).

11	*Alstonia scholaris* (R. Br.).	*shaitan-wood*	North Mangalore Division, Madras.	All tests finished	....	*hale*.
12	*Altingia excelsa* (Noronha).	*jutili*	Lakhimpur Division, Assam	Green tests finished	Assam	*jutili* (Assam).
13	*Amoora rohituka* (W. and A.).	*amoora*	Nowgong Division, Assam	Awaiting test	....	....
14	*Amoora spp.* (Roxb.)	*amoora*	Katha Division, Burma	Awaiting test	Assam and Bengal	*amari* (Assam) and *lali* (Bengal).
15	*Arisoptera glabra* (Kurz.)	..	Insein Division, Burma	Green tests finished	....	*kaunghmu*.
16	*Anogeissus acuminata* (Wall.).	*yon*	Pyinmana Division, Burma	All tests finished	Burma	*yon* (Burma).
17	*Anogeissus latifolia* (Wall.).	axle-wood	Dehra Dun Division, U. P.	All tests finished	United Provinces, Central Provinces, Bihar and Orissa, Bombay and Madras.	*bakli*, *dhao* (U. P.), *dhaura* (C. P.) and (B. & O.), *dindal*, *dhauda* (Bombay).
18	*Anogeissus latifolia* (Wall.).	axle-wood	South Coimbatore Division, Madras.	All tests finished	United Provinces, Central Provinces, Bihar and Orissa, Bombay and Madras.	*bakli*, *dhao* (U. P.), *dhaura* (C. P.) and (B. & O.), *dindal*, *dhauda* (Bombay).
19	*Artocarpus chaplasha* (Roxb.).	*chaplash*	Lakhimpur Division, Assam	Green tests finished	Assam	*sam*, *cham* (Assam).
20	*Artocarpus hirsuta* (Lamk.).	*aini*	South Mangalore Division, Madras.	All tests finished	Madras	*aini* (Madras).
21	*Bassia butyracea* (Roxb.)	..	South Andaman	Awaiting test	....	*hill mohwa*.
22	*Bassia latifolia* (Roxb.)	..	Jubbulpore and Narsingpur Divisions, C. P.	All tests finished	....	*mahua*.
23	*Berrya ammonilla* (Roxb.).	Trincomalee wood	Insein Division, Burma	All tests finished	....	*petwun*.
24	*Bischofia javanica* (Blume).	bishop wood	South Coimbatore Division, Madras.	All tests finished	....	*sholavengai*.
25	*Bombax insigne* (Wall.)	*didu*	South Andaman	All tests finished	Assam	*simul*, *himolu* (Assam).
26	*Bombax malabaricum* (DC.).	*semul*	Dehra Dun Division, U. P.	All tests finished	United Provinces, Bihar and Orissa, Bengal, Assam, Bombay and Burma.	*semal* (U. P.), *simuli* (B. & O.), *simal* (Bengal), *simul*, *himolu* (Assam), *sayar* (Bombay) and *letpan* (Burma).

APPENDIX—*contd.*

Index of the species of timber received for test, the progress and the provinces in which they are of economic importance—contd.

Serial No.	Botanical Name (Authority).	Trade Name.	Locality from which received for testing.	Progress.	Localities where it is of economic importance.	Common names in those localities.
27	*Boswellia serrata* (Roxb.)	*salai*	Hazaribagh Division, B. & O.	All tests finished	Central Provinces	*salai* (C. P.).
28	*Bridelia retusa* (Spreng)	..	Saranda Division, B. & O.	Awaiting test	....	*kaja.*
29	*Calophyllum elatum* (Bedd.).	*poon*	South Coimbatore Division, Madras.	All tests finished	Bombay and Madras	*nagari, srihoni* (Bombay) and *poon* (Madras).
30	*Calophyllum spp.* (Linn.)	*poon*	Cachar Division, Assam	Awaiting test	....	*telo.*
31	*Calophyllum tomentosum* (Syn. *Calophyllum elatum*) (Wight.).	*poon*	South Kanara Division, Bombay.	All tests finished	Bombay and Madras	*nagari, srihoni* (Bombay) and *poon* (Madras).
32	*Calophyllum wightianum* (Wall.)	*poon*	South Kanara Division, Bombay.	All tests finished	....	....
33	*Canarium euphyllum* (Kurz.).	*white dhup*	South Andaman	All tests finished	....	*white dhup.*
34	*Canarium strictum* (Roxb.).	*white dhup*	North Mangalore Division, Madras.	All tests finished *	....	*rala dhupa.*
35	*Carallia integerrima* (DC.).	*carallia*	Nowgong Division, Assam	Awaiting test	....	....
36	*Carapa moluccensis* (Lam.).	*pussur*	Tavoy Division, Burma	All tests finished	....	*kyathnan, kyana.*
37	*Careya arborea* (Roxb.).	..	Haldwani Division, U. P.	All tests finished	....	*kumbi.*
38	*Castanopsis hystrix* (A. DC.).	..	Darjeeling Division, Bengal	Awaiting test	Bengal	*katus* (Bengal).
39	*Casuarina equisetifolia* (Forst.).	Australian beef-wood.	Puri Division, B. & O.	Green tests finished	....	*jhaw.*
40	*Cedrela serrata* (Royle)	*toon*	Maymyo Division, Burma	All tests finished	Assam	*poma* (Assam).

41	*Cedrela toona* (Roxb.). .	*toon* . . .	Dehra Dun Division, U. P.	All tests finished *	Punjab, Bengal, Assam, Madras and Burma.	*tun* (Punjab), Bengal), *poma* (Assam), *thitkado* (Burma).
42	*Cedrus deodara* (Loudon)	deodar . .	Simla Division, Punjab .	All tests finished	Punjab and United Provinces.	*diar* (Punjab), deodar (U. P.).
43	*Chloroxylon swietenia* (DC.).	East Indian satinwood.	Hoshangabad Division, C. P.	Green tests finished	....	*ghiria*.
44	*Chloroxylon swietenia* (DC.).	East Indian satinwood.	Vizagapatam Division, Madras.	All tests finished	....	*billu*.
45	*Chukrasia tabularis* (Adr. Juss.).	chickrassy . .	Buxa Division, Bengal .	All tests finished	Assam, Madras and Burma	*boga-poma* (Assam), *yinma* (Burma).
46	*Chukrasia tabularis* (Adr. Juss.).	chickrassy . .	Katha Division, Burma .	Awaiting test .	Assam, Madras and Burma	*boga-poma* (Assam), *yinma* (Burma).
47	*Cinnamomum iners* (Reinw.).	cinnamon . .	Tavoy Division, Burma .	Awaiting test .	....	*hmanthin*.
48	*Cinnamomum inunctum* (Meissn.).	cinnamon . .	Tavoy Division, Burma .	Green tests finished	....	*karawe*.
49	*Cryptomeria japonica* (Don.).	..	Darjeeling Division, Bengal	All tests finished	Bengal	*dhupi* (Bengal).
50	*Cullenia excelsa* (Wight.).	*karani* . .	Forest Exploitation Division, Madras.	All tests finished	Madras	*chakka*.
51	*Cupressus torulosa* (Don.).	Himalayan cypress	Garhwal Division, U. P. .	Green tests finished	....	....
52	*Cynometra polyandra* Roxb.).	..	Sylhet Division, Assam .	All tests finished	....	*ping*.
53	*Dalbergia latifolia* (Roxb.).	Indian rosewood .	South Chanda Division, C. P.	All tests finished	Central Provinces, Bombay and Madras.	*shisham* (C. P.), (Bombay) *veeti* (Madras).
54	*Dalbergia latifolia* (Roxb.).	Indian rosewood .	Wynaad Division, Madras	Awaiting test .	Central Provinces, Bombay and Madras.	*shisham* (C. P.), (Bombay) *veeti* (Madras).
55	*Dalbergia sissoo* (Roxb.)	*sissoo* . .	Dehra Dun Division, U. P.	All tests finished	Punjab, United Provinces, and Bihar and Orissa.	*shisham* (Punjab), *shisham* and *sissoo* (U. P.), *sissu* (B. & O.).

* Data not reliable due to fungus.

APPENDIX—*contd.*

Index of the species of timber received for test, the progress and the provinces in which they are of economic importance—contd.

Serial No.	Botanical Name (Authority).	Trade Name.	Locality from which received for testing.	Progress.	Localities where it is of economic importance.	Common names in those localities.
56	*Dalbergia sissoo* (Roxb.)	*sissoo* . . .	Hazaribagh Division, B. & O.	All tests finished	Punjab, United Provinces, and Bihar and Orissa.	*shisham* (Punjab), *shisham* and *sissoo* (U. P.), *sissu* (B. & O.).
57	*Dichopsis elliptica* (Benth.).	*pali* . . .	Forest Exploitation Division, Madras.	All tests finished	....	*pali.*
58	*Dillenia indica* (Linn.) .	..	Chittagong Hill Tracts, Bengal.	All tests finished	....	*chalta.*
59	*Dillenia pentagyna* (Roxb.).	*dillenia* . .	Buxa Division, Bengal .	All tests finished	....	*tatri.*
60	*Diospyros melanoxylon* (Roxb.).	ebony . .	South Chanda Division, C. P.	All tests finished	....	*temru, tumri.*
61	*Dipterocarpus alatus* (Roxb.).	*gurjun* . .	Insein Division, Burma .	All tests finished	Bengal and Burma . .	*garjan* (Bengal), *in* (Burma).
62	*Dipterocarpus griffithii* (Miq.).	*gurjun* . .	Insein Division, Burma .	All tests finished	....	*kanyin-byan.*
63	*Dipterocarpus griffithii* (Miq.).	*gurjun* . .	North Andaman . .	All tests finished	....	*gurjun.*
64	*Dipterocarpus kerrii* .	..	Mergui Division, Burma .	All tests finished	....	*kanyin-byan, aebin.*
65	*Dipterocarpus macrocarpus.*	*hollong* . .	Lakhimpur Division, Assam	All tests finished	Bengal and Assam . .	*garjan* (Bengal), *hollong* (Assam).
66	*Dipterocarpus tuberculatus* (Roxb.).	*eng* . . .	Insein Division, Burma .	All tests finished	Burma	*in* (Burma).
67	*Dipterocarpus turbinatus* (Dyer.).	*gurjun* . .	Insein Division, Burma .	All tests finished	Bengal, Assam and Burma	*garjan* (Assam), *kanyin* (Burma).

68	*Duabanga sonneratioides* (Ham.).	*lampatti*	Kurseong Division, Bengal	All tests finished	....	*lampati*.
69	*Dysoxylum malabaricum* (Bedd.).	white cedar	South Coimbatore Division, Madras.	All tests finished	Madras	*agil*.
70	*Engelhardtia spicata* (Bl.).	..	Cachar Division, Assam	Awaiting test	....	mogial poma.
71	*Eugenia gardneri*	*jaman*	Mangalore South Division, Madras.	All tests finished	Madras	....
72	*Eugenia jambolana* (Lam.).	*jaman*	Gonda Division, U. P.	All tests finished	United Provinces, Bihar and Orissa, and Bombay.	*jaman* (U. P.), *jaman*, *jambu* (B. & O.), *jambul* (Bombay).
73	*Eugenia spp.* (Linn.)	*jaman*	Cachar Division, Assam	Awaiting test	....	*pahari jam*.
74	*Fraxinus excelsior* (Linn.)	European ash	Chamba State, Punjab	Green tests in progress.	....	....
75	*Garuga pinnata* (Roxb.)	*garuga*	Dehra Dun Division, U. P.	All tests finished	....	*kharpat*.
76	*Gmelina arborea* (Roxb.)	*gumhar*	Haldwani Division, U. P.	All tests finished	Bihar and Orissa, and Burma.	*gamhari* (B. & O.), *yemane* (Burma).
77	*Gmelina arborea* (Roxb.)	*gumhar*	Insein Division, Burma	Green tests finished	Bihar and Orissa, and Burma.	*gamhari* (B. & O.), *yemane* (Burma).
78	*Grewia tiliæfolia* (Vahl.)	*dhaman*	Wynaad Division, Madras	All tests finished	Bombay and Madras	*dhaman* (Bombay).
79	*Hardwickia binata* (Roxb.).	*anjan*	Nimar Division, C. P.	All tests finished	Bombay and Madras	*anjan* (Bombay).
80	*Heritiera minor* (Roxb.)	*sundri*	Delta Division, Burma	All tests finished	Burma	(*pinle*) *kanango* (Burma).
81	*Heritiera spp.* (Aiton.)	*sundri*	Cachar Division, Assam	Awaiting test	....	....
82	*Heterophragma adenophyllum* (Seem.).	Karen wood	Pyinmana Division, Burma	All tests finished	....	*petthan*.
83	*Heterophragma roxburghii* (DC.).	..	South Chanda Division, C. P.	Awaiting test	....	*polong*.
84	*Holoptelea integrifolia* (Planch.).	Indian elm	Dehra Dun Division, U. P.	All tests finished	....	*kalipapri*, *kanjoo*.
85	*Homalium tomentosum* (Benth.)	Burma lancewood.	Pyinmana Division, Burma	All tests finished	Burma	*myauk chaw* (Burma).

APPENDIX—*contd.*

Index of the species of timber received for test, the progress and the provinces in which they are of economic importance—contd.

Serial No.	Botanical Name (Authority).	Trade Name.	Locality from which received for testing.	Progress.	Localities where it is of economic importance.	Common names in those localities.
86	*Hopea glabra* (W. & A.)	..	Palghat Division, Madras	All tests finished	....	*kong.*
87	*Hopea odorata* (Roxb.)	*thingan*	South Tenasserim Division, Burma.	All tests finished	Burma	*thingan* (Burma).
88	*Hopea parviflora* (Bedd.)	*hopea*	South Mangalore Division, Madras.	All tests finished	Madras	*kiralboghi, irumbogam* (Madras).
89	*Hymenodictyon excelsum* (Wall.).	*kuthan*	Ramnagar Division, U. P.	All tests finished	....	*borang.*
90	*Isonandra spp.* (Wight.)	..	Cachar Division, Assam	Awaiting test	....	*kurta.*
91	*Juglans fallax*	walnut	Jhelum Valley, Kashmir	All tests finished	....	....
92	*Kayea floribunda* (Wall.)	..	Cachar Division, Assam	Awaiting test	...	*kurai.*
93	*Lagerstræmia flos-reginæ* (Retz.).	*jarul*	Chittagong Hill Tracts, Bengal.	All tests finished	Assam and Burma	*ajhar, jarul* (Assam), *pyinma* (Burma).
94	*Lagerstræmia hypoleuca* (Kurz.).	Andaman *pyinma*	North Andaman	All tests finished	....	*pyinma.*
95	*Lagerstræmia lanceolata* (Bedd.).	*benteak*	Nilambur Division, Madras	Awaiting test	Bombay and Madras	*nandi, nana* (Bombay).
96	*Lagerstræmia lanceolata* (Bedd.), (Syn. *Lagerstræmia microcarpa* (Wight.).	*benteak*	North Kanara Division, Bombay.	All tests finished	Bombay and Madras	*nandi, nana* (Bombay).
97	*Lagerstræmia parviflora* (Roxb.).	*lendi*	Dehra Dun Division, U. P.	All tests finished	United Provinces and Madras.	*dhauri* (U. P.), *ventek* (Madras).
98	*Lagerstræmia tomentosa* (Presl.).	*leza*	Pyinmana Division, Burma	All tests finished	Burma	*leza* (Burma).

99	*Lannea grandis* . .	*jhingan* . .	Dehra Dun Division, U. P.	All tests finished	....	*j hingan.*
100	*Lophopetalum wightianum* (Arn.).	*banati* . .	North Mangalore Division, Madras.	All tests finished *	....	*bol pale.*
101	*Machilus macrantha* (Nees.).	ladder wood .	North Mangalore Division, Madras.	All tests finished	....	*gulmav.*
102	*Machilus odoratissima* (Nees.)	ladder wood .	Kurseong Division, Bengal	All tests finished	....	*lali kawla.*
103	*Mallotus philippinensis* (Muell. Arg.).	..	Dehra Dun Division, U. P.	Awaiting test .	....	*raini.*
104	*Mangifera indica* (Linn.)	mango . .	Puri Division, B. & O. .	All tests finished	Punjab, United Provinces, Bombay, Madras and Burma.	*am, amb* (Punjab), *am* (U. P.), *mavin amba* (Bombay), *thayet* (Burma).
105	*Melanorrhœa usitata* (Wall.).	*thitsi* . . .	Meiktila Division, Burma .	All tests finished	....	*thitsi.*
106	*Mesua ferrea* (Linn.) .	*mesua* . .	Sibsagar Division, Assam .	All tests finished	Assam and Madras . .	*nahor* (Assam), *surli* (Madras).
107	*Michelia cathcartii* (Hook. f. and Th.).	..	Kurseong Division, Bengal	All tests finished	....	*tita champ.*
108	*Michelia champaca* (Linn.)	*Champak* . .	Kurseong Division, Bengal	All tests finished	Assam	*chopa* (Assam).
109	*Michelia excelsa* (Bl.) .	..	Kurseong Division, Bengal	All tests finished	Bengal	(*mitha*) *champ* (Bengal).
110	*Michelia montana* (Bl.) .	..	Jalpaiguri Division, Bengal	Green tests finished	....	*tita champ.*
111	*Michelia oblonga* (Wall.).	..	Buxa Division, Bengal, North Circle.	Green tests finished	....	*champ.*
112	*Miliusa velutina* (Hook. f. and Th.).	..	Dehra Dun Division, U. P.	Awaiting test .	....	*domsal.*
113	*Mimusops elengi* (Linn.)	bullet wood .	South Coimbatore Division, Madras.	Awaiting test .	....	*magadam.*
114	*Mimusops littoralis* (Kurz.).	bullet wood .	South Andaman . .	Awaiting test .	....	....

* Data not reliable due to fungus.

APPENDIX—*contd.*

Index of the species of timber received for test, the progress and the provinces in which they are of economic importance—contd.

Serial No.	Botanical Name (Authority).	Trade Name.	Locality from which received for testing.	Progress.	Localities where it is of economic importance.	Common names in those localities.
115	*Mitragyna diversifolia* (Havil.).	*binga* . .	Pyinmana Division, Burma	All tests finished	....	*binga*.
116	*Mitragyna parvifolia* (Havil.).	*kaim* . . .	Haldwani Division, U. P. .	All tests finished	Bombay	*kalamb* (Bombay).
117	*Morus alba* (Linn.) .	mulberry . .	North Plantation Division, Punjab.	All tests finished	Punjab	*tut* (Punjab).
118	*Morus serrata* (Roxb.) .	mulberry . .	Chamba State, Punjab .	All tests finished	....	....
119	*Myristica attenuata* (Wall.).	..	North Mangalore Division, Madras.	All tests finished *	....	*kad pindi.*
120	*Ougeinia dalbergioides* (Benth.).	*sandan* . .	Hoshangabad Division, C. P.	Green tests finished	Central Provinces, Bihar and Orissa, and Bombay.	*tinsa* (C. P.), *bandhan, panjan* (B. & O.), *tiwas* (Bombay).
121	*Parashorea stellata* (Kurz.).	Tavoy wood .	Tharrawaddy Division, Burma.	All tests finished	....	....
122	*Parishia insignis* (Hook. f.).	*red dhup* . .	South Andaman . .	All tests finished	....	*red dhup*.
123	*Pentace burmanica* (Kurz.).	*thitka* . .	....	All tests finished	Burma	*thitka* (Burma).
124	*Pentace griffithii* (King.).	..	Tavoy Division, Burma .	Awaiting test .	....	*thitkaho.*
125	*Pentacme suavis* (Ad. C.)	Burma *sal* . .	Pyinmana Division, Burma	All tests finished	Burma	*ingyin* (Burma).
126	*Phœbe hainesiana* . .	*bonsum* . .	Nowgong Division, Assam	All tests finished	Assam	*bonsum* (Assam).
127	*Picea morinda* (Linn.) .	Himalayan spruce	Simla Division, Punjab .	All tests finished	Punjab and United Provinces.	*tos, rai* (Punjab), *raga* (U. P.).

128	*Pinus excelsa* (Wall.)	blue pine	Rawalpindi West, Punjab	All tests finished	Punjab	*kail*, *biar*, *ilm*, (Punjab).
129	*Pinus longifolia* (Roxb.).	*chir*	Rawalpindi East, Punjab	All tests finished	Punjab and United Provinces.	*chil*, *shti* (Punjab), *chir* (U. P.).
130	*Pinus longifolia* (Roxb.).	*chir*	Ranikhet Division, U. P.	All tests finished	Punjab and United Provinces.	*chil*, *shti* (Punjab), *chir* (U. P.).
131	*Pinus longifolia* (Roxb.).	*chir*	Dehra Dun Division, U. P.	All tests finished	Punjab and United Provinces.	*chil*, *shti* (Punjab), *chir* (U.P.).
132	*Planchonia andamanica*	*red bombway*	South Andaman	All tests finished	....	*red bombwe*.
133	*Podocarpus neriifolia* (Don.).	*thitmin*	South Andaman	All tests finished	....	*thitmin* (Burma), *halis lakri* (Hindi).
134	*Pœciloneuron indicum* (Bedd.)	..	North Mangalore Division, Madras.	Awaiting test	....	..
135	*Polyalthia fragrans* (Benth. and Hook. f.).	..	Chenat Nair Exploitation Division, Madras.	All tests finished	....	....
136	*Pongamia glabra* (Vent.)	..	East Kanara Division, Bombay.	Awaiting test	....	*saykaranji*.
137	*Pterocarpus dalbergioides* (Roxb.).	Andaman *padauk*	North Andaman	All tests finished	....	Andaman *padauk*.
138	*Pterocarpus macrocarpus* (Kurz.).	Burma *padauk*	Mogok Division, Burma	All tests finished	Burma	*padauk* (Burma).
139	*Pterocarpus marsupium* (Roxb.).	*bijasal*	Belgaum Division, Bombay	All tests finished	Central Provinces, Bihar and Orissa, Bombay and Madras.	*bija* (C. P.), *bija*, *pisal* (B. & O.), *honne*, *beo* (Bombay) *vengai* (Madras).
140	*Pterocarpus santalinus*	red sanders	South Cuddapah Division, Madras.	Awaiting test	Madras	*erra chandanam*, red sanders, *rakta chandan*.
141	*Pterospermum acerifolium* (Willd.).	..	Buxa Division, Bengal	All tests finished	....	*hattipaila* (Nepal).
142	*Quercus lamellosa* (Smith.).	..	Darjeeling Division, Bengal	Green tests finished	Bengal	*buk* (Bengal).
143	*Quercus lineata* (Blume.)	..	Darjeeling Division, Bengal	Green tests in progress.	Bengal	*phalat* (Bengal).

* Data not reliable due to fungus.

APPENDIX—*contd.*

Index of the species of timber received for test, the progress and the provinces in which they are of economic importance—contd.

Serial No.	Botanical Name (Authority).	Trade Name.	Locality from which received for testing.	Progress.	Localities where it is of economic importance.	Common names in those localities.
144	*Saccopetalum tomentosum* (Hook. f. and Th.).	..	East Kanara Division, Bombay.	Awaiting test .	....	*womb.*
145	*Sageræa listeri* (King) .	*chooi* . . .	South Andaman . . .	All tests finished	....	*chooi.*
146	*Schima wallichii* (Choisy)	needle wood .	Buxa Division, Bengal .	All tests finished	Bengal and Assam . .	*chilauni* (Bengal), *nagabheh* (Assam).
147	*Schleichera trijuga* (Willd.).	*kusum* . .	Pyinmana Division, Burma	All tests finished	....	*gyo.*
148	*Shorea assamica* (Dyer.)	*makai* . .	Lakhimpur Division, Assam	All tests finished	Assam	*makai* (Assam).
149	*Shorea obtusa* (Wall.) .	Burma *sal* . .	Pyinmana Division, Burma	All tests finished	Burma	*thitya* (Burma).
150	*Shorea robusta* (Gærtn. f.)	*sal* . . .	Balaghat Division, C. P. .	All tests finished	Punjab, United Provinces, Central Provinces, Bihar and Orissa, Bengal, Assam and Madras.	*sal* (Punjab), (U. P.), (C. P.), (B. & O.), (Bengal), and (Assam).
151	*Shorea robusta* (Gærtn. f.)	*sal* . . .	Kalimpong, Jalpaiguri Divisions, Bengal.	All tests finished	Punjab, United Provinces, Central Provinces, Bihar and Orissa, Bengal, Assam and Madras.	*sal* (Punjab), (U. P.), (C. P.), (B. & O.), (Bengal), and (Assam).
152	*Shorea robusta* (Gærtn. f.)	*sal* . . .	Gorakhpur, North Kheri and Haldwani Divisions, U. P.	All tests finished	Punjab, United Provinces, Central Provinces, Bihar and Orissa, Bengal, Assam and Madras.	*sal* (Punjab), (U. P.), (C. P.), (B. & O.), (Bengal), and (Assam).
153	*Sonneratia apetala* (Ham.).	..	Sunderbans Division, Bengal.	All tests finished	....	*keowra.*
154	*Stereospermum chelonoides* (DC.).	*padri* . .	Buxa Division, Bengal .	All tests finished	....	*parari* (Nepal).
155	*Stereospermum chelonoides* (DC.).	*padri* . . .	South Mangalore Division, Madras.	Awaiting test .	....	*adikai.*

156	*Stereospermum suaveolens* (DC.).	..	Dehra Dun Division, U. P.	All tests finished	....	*padal.*
157	*Stereospermum xylocarpum* (Benth and Hook. f.).	..	South Coimbatore Division, Madras.	Awaiting test .	....	*vedankomai.*
158	*Swintonia floribunda* .	..	Insein Division, Burma .	All tests finished	....	*taungthayet, shitle.*
159	*Tectona grandis* (Linn. f.)	teak . . .	Malabar Division, Madras .	All tests finished	Central Provinces, Bihar and Orissa, Bombay, Madras and Burma.	*sagwan* (B. & O.), *sag* (Bombay), and *kyun* (Burma).
160	*Tectona grandis* (Linn. f.)	teak . . .	Hoshangabad and South Chanda Divisions, C. P.	All tests finished	Central Provinces, Bihar and Orissa, Bombay, Madras and Burma.	*sagwan* (B. & O.), *sag* (Bombay), and *kyun* (Burma).
161	*Tectona grandis* (Linn. f.)	teak . . .	Zigon Division, Burma .	All tests finished	Central Provinces, Bihar and Orissa, Bombay, Madras and Burma.	*sagwan* (B. & O.), *sag* (Bombay), and *kyun* (Burma).
162	*Tectona grandis* (Linn. f.)	teak . . .	Puri and Angul Divisions, B. & O.	All tests finished	Central Provinces, Bihar and Orissa, Bombay, Madras and Burma.	*sagwan* (B. & O.), *sag* (Bombay), and *kyun* (Burma).
163	*Terminalia arjuna* (Bedd.).	..	Kolhan Division, B. & O. .	All tests finished	....	*arjun, gara hatna.*
164	*Terminalia belerica* (Roxb.).	*bahera* . .	Insein Division, Burma .	All tests finished	....	*thitsein, bahera.*
165	*Terminalia bialata* (Wall).	*white chuglam* .	South Andaman . .	All tests finished	....	*white chuglam.*
166	*Terminalia chebula* (Retz.).	myrabolan . .	Insein Division, Burma .	All tests finished	....	*panga.*
167	*Terminalia manii* (King.)	*black chuglam* .	South Andaman . .	All tests finished	....	*black chuglam.*
168	*Terminalia myriocarpa* (Haurck and Mell. Arg.).	*holloek* . .	Lakhimpur Division, Assam	Awaiting test .	Bengal and Assam . .	*pani saj* (Bengal), *hollork* (Assam).
169	*Terminalia paniculata* (W. and A.).	*kindal* . .	Nilambur Division, Madras	All tests finished	Bombay and Madras. .	*kindal* (Bombay), *pillamarudu* (Madras).
170	*Terminalia paniculata* (W. and A.).	*kindal* . .	East Kanara Division, Bombay.	All tests finished	Bombay and Madras .	*kindal* (Bombay), *pillamarudu* (Madras).

APPENDIX—*contd.*

Index of the species of timber received for test, the progress and the provinces in which they are of economic importance—concld.

Serial No.	Botanical Name (Authority).	Trade Name.	Locality from which received for testing.	Progress.	Localities where it is of economic importance.	Common names in those localities.
171	*Terminalia procera* (Roxb.).	*white bombway* .	North Andaman . .	All tests finished	....	*white bombwe.*
172	*Terminalia pyrifolia* (Kurz.).	..	Pyinmana Division, Burma	All tests finished	....	*lein.*
173	*Terminalia tomentosa* (W. and A.).	laurel . .	Ramnagar Division, U. P.	All tests finished	United Provinces, Central Provinces, Bihar and Orissa, Bengal, Bombay, Madras and Burma.	*sain, asna, saj* (U. P.), *saj* (C. P.), *asan* (B. & O.), (*pakha-*) *saj* (Bengal), *matti, ain* (Bombay), *karimarudu* (Madras) and *taukkyan* (Burma).
174	*Terminalia tomentosa* (W. and A.).	laurel . .	Wynaad Division, Madras	All tests finished	United Provinces, Central Provinces, Bihar and Orissa, Bengal, Bombay, Madras and Burma.	*sain, asna, saj* (U. P.), *saj* (C. P.), *asan* (B. & O.), (*pakha-*) *saj* (Bengal), *matti, ain* (Bombay), *karimarudu* (Madras) and *taukkyan* (Burma).
175	*Ulmus wallichiana* (Planch.).	elm . . .	Chamba State, Punjab .	Awaiting test .	....	....
176	*Vateria indica* (Linn.) .	*vellapiney* . .	North Mangalore Division, Madras.	All tests finished	Madras	*dhupa.*
177	*Vitex altissima* (Linn.) .	*milla* . . .	East Kanara Division, Bombay.	Awaiting test .	....	*balgi.*
178	*Xylia dolabriformis* (Benth.).	*pyinkado* . .	Tharrawaddy Division, Burma.	All tests finished	Burma	*pyingado, pyinkado* (Burma).
179	*Xylia xylocarpa* . .	*irul* . . .	North Kanara Division, Bombay.	All tests finished	Bihar and Orissa, Bombay, and Madras.	*kongra* (B. & O.), *jamba* (Bombay) and *irul* (Madras).

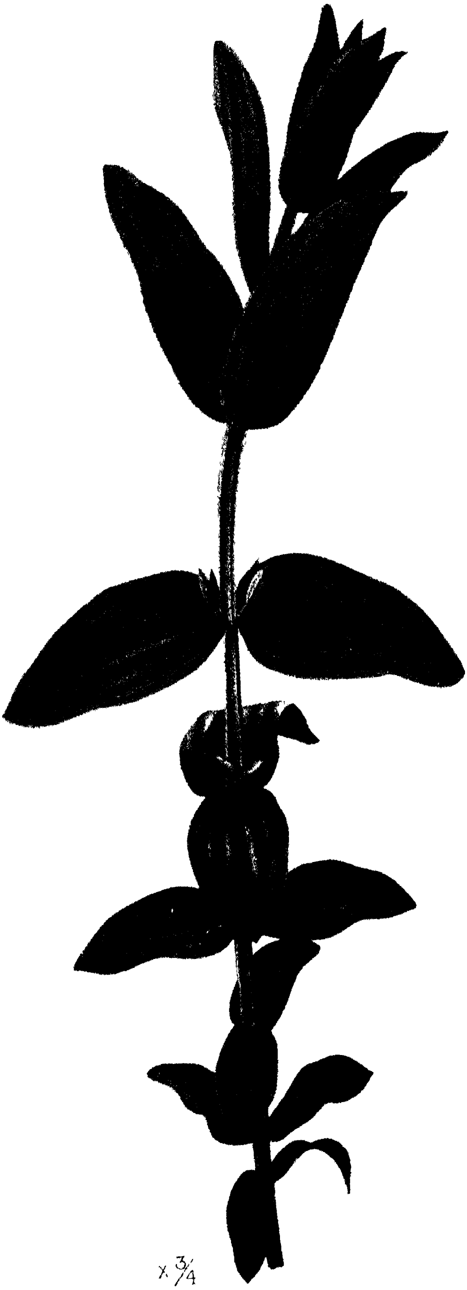
TABLE No. 3.—PHYSICAL AND MECHANICAL PROPERTIES OF WOODS GROWN IN INDIA.

Serial No.	Species.	Locality.	Number of trees.	Seasoning.	Rings per inch.	SPECIFIC GRAVITY BASED ON WEIGHT OVEN DRY AND		Moist. % at test.	WEIGHT IN LBS. PER CU. FT.		SHRINKAGE % GREEN TO OVEN DRY.			STATIC BENDING.						IMPACT BENDING.				COMPRESSION PARALLEL TO GRAIN.			COMP. PERP. TO GRAIN.	HARDNESS. LOAD IN LBS			SHEAR.		TENSION.	
																	Work in inch—lbs. per cu. inch.																	
						Volume at test.	Volume oven dry.		At test.	At 12 % moisture.	Radial.	Tangential.	Volumetric.	F. S at E. L lbs. per Sq in.	M. of R. lbs per Sq in.	M. of E 1,000 lbs per Sq in	To E L.	To Max. Load.	Total.	F. S. at E. L. lbs. per Sq in.	Max. Drop in inches.	M of E 1,000 lbs per Sq in	Work to E. L in inch—lbs. per cu inch	Compressive Stress at E. L. lbs per Sq in	Max. Crushing Stress lbs per Sq in	M of E. 1,000 lbs per Sq in	Compressive Stress at E. L. lbs per Sq. in.	Radial	Tangential	End	Radial lbs per Sq in.	Tangential lbs per Sq in.	Radial lbs per Sq in.	Tangential lbs. per Sq in.
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35
	Tectona grandis (teak)	Burma and Malabar.	14	G	10	598	·629	51 8	57	.	2·3	4·2	6 8	7,090	11,435	1,073	1·70	9 3	27 1	16,745	35	2,183	7 23	4,075	5,870	1,937	1,055	1,045	1,030	915	1,045	1,170	525	695
			..	*A D.*	..	*·611*	..	*13·9*	*43*	*43*	..	..	..	*9,175*	*13,910*	*1,818*	*2 62*	*10.4*	*25·1*	*18,940*	*27*	*2,376*	*8·40*	*5,390*	*7,900*	*2,033*	*1,405*	*1,'25*	*1,115*	*1,050*	*1,220*	*1,415*	*540*	*640*
1	Abies pindrow (Himalayan silver fir)	Simla, (Punjab)	4	G	21	·447	·488	49·9	42		3 6	8·0	11·8	4,740	7,785	1,451	0 91	6 8	17·8	10,410	22	1,567	3 98	2,890	3,700	1,768	560	500	515	610	790	845	235	270
			.	*A. D*	..	*·468*	..	*12·8*	*33*	*33*	..	.	.	*7,455*	*11,725*	*1,631*	*1 96*	*8 9*	*18·3*	*14,270*	*24*	*2,344*	*4 92*	*5,710*	*7,045*	*2,034*	*1,065*	*'10*	*930*	*1,115*	*1,275*	*980*	*235*	*180*
2	Acacia arabica (*babul*)	Hyderabad, (Sind)	5	G.	..	·708	·777	63·3	72		2·7	6 7	9 7	7,950	13,090	1,541	2 33	15 7	47·5	20,585	65	1,993	12 11	4,650	6,440	1,538	1,625	2,015	1,965	2,040	1,750	2,260	810	1,170
			.	*A. D.*	..	*·740*	..	*12·0*	*52*	*52*	..	..	.	*11,485*	*19,110*	*1,706*	*4 28*	*19·3*	*33·3*	*19,575*	*48*	*2,790*	*7 96*	*6,230*	*10,215*	*1,812*	*2,250*	*2,405*	*2,335*	*2,520*	*2,170*	*2,745*	*565*	*720*
3	Acrocarpus fraxinifolius (*mundani*)	Malabar, (Madras)	5	G	.	·587	·633	95·3	71	.	3·0	5 2	9 7	7,045	11,475	1,791	1 66	9·7	25·8	14,115	32	2,185	5 14	4,265	5,995	1,812	1,140	1,265	1,275	1,205	1,575	1,610	750	770
			.	*A. D.*	..	*606*		*13·8*	*43*	*42*	..	..	.	*9,760*	*14,850*	*2,104*	*2 69*	*13·5*	*25 9*	*15,415*	*37*	*2,445*	*5·49*	*4,550*	*6,745*	*1,877*	*965*	*1,080*	*1,230*	*1,235*	*1,645*	*1,455*	*740*	*925*
4	Adina cordifolia (*haldu*)	Haldwani, (U. P)	5	G.	..	·583	628	81·4	66		2·8	5·6	8 7	5,645	9,450	1,215	1 50	8 0	19·6	11,885	29	1,521	5 20	3,955	4,925	1,181	1,085	1 060	1,100	1,255	1,150	1,320	645	685
				A D	.	*·592*	..	*12 2*	*41*	*41*	..	..	..	*6,535*	*11,325*	*1,362*	*1 76*	*7 0*	*20 4*	*13,075*	*19*	*2,280*	*4 22*	*4,175*	*6,550*	*1,193*	*1,475*	*1,165*	*1,295*	*1,440*	*1,505*	*1,490*	*370*	*615*
5	Adina cordifolia (*haldu*)	South Coimbatore, (Madras)	5	G	..	·614	·659	47.9	57	.	2·8	5 4	8 7	5,075	9,345	1,270	1 17	8 8	19·5	12,605	31	1,802	4 95	3,090	4,545	1,3[illegible]2	790	970	955	1,065	1,065	1,205	580	650
				A. D.	..	*613*	..	*14·6*	*44*	*43*	.	..	.	*6,305*	*10,450*	*1,445*	*1 76*	*7 3*	*19·7*	*12,670*	*26*	*1,843*	*4 90*	*3,215*	*5,995*	*1,[illegible]8*	*1*	*,225*	*1,175*	*1,405*	*1,160*	*1,345*	*350*	*625*
6	Adina cordifolia (*haldu*)	Saranda, (B and O)	5	G	.	·597	·652	66·0	62	.	3 2	6 0	10 8	6,250	10,420	1,412	1 61	9·9	27·5	13,400	34	1,697	6 01	3,350	5,000	1,[illegible]0		,015	1,055	1,140	1,160	1,320	645	745
			..	*A. D.*	..	*·608*	..	*15·1*	*44*	*42*	..	..	.	*9,155*	*14,610*	*1,077*	*2 86*	*11 3*	*27·9*	*14,780*	*28*	*2,016*	*6 14*	*4,780*	*7,885*	*1,[illegible]*		*,465*	*1,540*	*1,680*	*1,660*	*1,510*	*725*	*750*
7	Ægle marmelos (*bel*)	Gonda, (U P.)	5	G	10	·754	·844	41 2	66	.	4 4	8·3	13 1	5,925	9,595	1,253	1 58	9 7	32·9	13,800	35	1,988	5 44	3,515	5,005	1,3		,975	1,890	1,925	1,675	1,940	640	795
			..	*A. D.*	..	*795*	..	*12·0*	*56*	*56*	..	..	..	*6,870*	*10,615*	*1,433*	*1 88*	*6 1*	*15 9*	*11,925*	*21*	*1,829*	*4 46*	*3,815*	*7,105*	*1,7*		*,500*	*2,315*	*2,455*	*1,970*	*2,530*	*550*	*1,955*
8	Albizzia lebbek (*kokko*)	South Andaman	5	G.	.	549	·584	73·6	59	..	2·9	5 8	9·6	6,035	9,560	1,589	1 32	8·3	22·8	14,040	30	2,345	4 77	3,585	5,005	1,6		,005	1,040	1,045	1,305	1,430	650	800
			.	*A. D.*	.	*·573*	..	*8·4*	*39*	*40*	..	.		*10,330*	*14,425*	*1,825*	*3 33*	*7·7*	*16 1*	*15,320*	*26*	*2,429*	*5 51*	*5,010*	*8,765*	*1,9*		*,210*	*1,285*	*1,240*	*1,685*	*2,005*	*425*	*515*
9	Albizzia procera (*white siris*)	Dehra Dun, (U. P)	5	G.	..	·579	·618	96·2	71	..	3·1	6·9	8·8	5,495	9,525	1,283	1 36	9 0	34·8	12,950	42	1,829	5 24	3,585	4,850	1,3		,275	1,245	1,220	1,075	1,450	480	610
			.	*A. D*	.	.	..	*15·3*	*43*	*41*	.	.	.	*6,660*	*12,820*	*1,461*	*1 83*	*17·7*	*32·6*	*16,345*	*51*	*2,209*	*6 83*	*1,585*	*6,875*	*1,5*		*920*	*965*	*1,065*	*1,750*	*1,915*	*830*	*920*
10	Alstonia scholaris (*shaitan wood*)	North Mangalore, (Madras)	5	G	..	·361	·387	74·1	39		3·1	4·9	9·0	3,645	5,135	897	0·85	3·3	6·7	9,100	16	1,353	3·46	2,290	2,790	9		375	395	495	650	745	315	405
				A. D.	..	*377*	..	*6 1*	*25*	*26*	..	..	..	*5,350*	*7,485*	*1,058*	*1 52*	*4 1*	*9·3*	*9,550*	*12*	*1,587*	*3 30*	*3,285*	*1,565*	*1,(*		*400*	*465*	*680*	*600*	*920*	*190*	*175*

Serial No.	Species.	Locality.	Number of trees.	Seasoning.	Ring per inch.	SPECIFIC GRAVITY BASED ON WEIGHT OVEN DRY AND	
						Volume at test.	Volume oven dry.
1	2	3	4	5	6	7	8
	Tectona grandis (teak)	Burma and Malabar	14	G.	10	·598	·629
			..	*A. D.*	..	*·611*	..
131	Terminalia manii (*black chuglam*) .	South Andaman .	5	G.	..	·665	·769
			..	*A. D.*	..	*·739*	..
132	Terminalia paniculata (*kindal*) . .	Nilambur, (Madras)	5	G.	9	·654	·746
			..	*A. D.*	..	*·703*	..
133	Terminalia paniculata (*kindal*) . .	East Kanara, (Bombay).	5	G.	..	·638	·715
			..	*A. D.*	..	*·683*	..
134	Terminalia procera (*white bombway*) .	North Andaman .	5	G	8	·520	·567
			..	*A. D.*	..	*·559*	..
135	Terminalia pyrifolia (*lein*) . . .	Pyinmana, (Burma)	5	G.	6	·631	·732
			..	*A. D.*	..	*·663*	..
136	Terminalia tomentosa (laurel) . .	Ramnagar, (U. P) .	5	G	8	·707	·807
			..	*A. D.*	..	*·752*	..
137	Terminalia tomentosa (laurel) . .	Malabar, (Madras) .	5	G.	..	·746	·849
			..	*A. D.*	..	*·809*	..
138	Vateria indica (*vellapiney*) . .	North Mangalore, (Madras).	4	G.	..	·483	·553
			..	*A. D.*	..	*·522*	..
139	Xylia dolabriformis (*pyinkado*) . .	Tharrawaddy, (Burma).	5	G.	9	·779	·868
			..	*A. D.*	..	*·816*	..
140	Xylia xylocarpa (*irul*)	North Kanara, (Bombay).	5	G.	..	·715	·801
			..	*A. D.*	..	*·749*	..

BAGCHEE   PERIDERMIUM

FRONTISPIECE



EXPLANATION OF FRONTISPIECE.

Drawing of *Swertia alata* showing infection *Cronartium himalayense*, uredostage. × ½.

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INVESTIGATIONS ON THE INFESTATION OF *PERIDERMIUM HIMALAYENSE*, BAGCHEE, ON *PINUS LONGIFOLIA*.

Part II. *Cronartium himalayense*, n. sp., on *Swertia* spp. Distribution, Morphology of the Parasite, Pathological study of the Infection, Biological Relationship with the Pine Rust, and Control.

BY

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I. INTRODUCTION.

In accordance with the idea that the hitherto unknown alternate stage of the blister rust of *chir* (*Pinus longifolia*, Roxb.) might be found at the close of the rainy season and within close proximity to the infected pine stands, a search was carried out in October 1927 to discover this stage. The outbreak of this disease which from early accounts appeared in sporadic form in some of the *chir* forests of Kumaon eventually appeared as a typical wide-spread epidemic involving heavy loss in the young pine stands in the Kumaon and Garhwal Himalayas. Reports of its spread to virgin and healthy regeneration, both artificial and natural, have been frequently received since this investigation was taken up in the early part of 1927.

From the previous field investigations, it appeared that the source of infection was, in all probability, not very far from the infected pine area. Some of the infected compartments stocked with young pine appeared quite isolated. In some of the areas the infected trees were separated from the nearest young and healthy growth by a compartment containing a more advanced and uneven-aged crop. Occasionally a ridge stocked with poles and mature trees separated the infected from the uninfected stands, while the ravines which formed the natural boundary of the compartments were generally grown with various broad-leaved species consisting mostly of *Pieris ovalifolia, Myrica nagi, Pyrus pashia, Cratægus crenulata, Rhus parviflora, Rosa moschata, Ficus* spp. and others.

In other areas, tracts of cultivated land often bordered by a mixed vegetation of various species of semi-wild and cultivated plants formed the boundary of these pine forests stocked with saplings and poles. These species growing on the edge of the forests and cultivated lands varied from one area to another.

The floor of the forest, on the other hand, was thickly covered by grasses, ferns and annual herbs, some of which had grown up to 3 ft. in height after the monsoon rains. Here, again, the species of these annual herbs varied from one area to another so much that even within the infected compartment any attempt to confine the search for the alternate host to a number of selected species which formed the so-called common associates of *chir* forest was considered useless. Consequently, the proposal to restrict the search to a few selected species of broad-leaved trees outside the infected compartments was ultimately given up.

It was decided to concentrate attention on one such isolated area and to make in it a thorough search on each and every species, without missing any, if possible, starting from within the compartment and gradually extending all round to a range of 200 yards.

After having conducted a general search inside the infected compartment it was considered well worth while to extend this to the ravines which demarcated these compartments. A list of species forming the associates of *Pinus longifolia* forests in Kumaon was also prepared. During the final search the broad-leaved species and ferns which formed the common associates of pine were carefully examined for such rusts that could tentatively be taken as the possible alternate stage of *Peridermium himalayense* for inoculation experiments.

The search was started in compartment 2 at Kaligadh block, Ranikhet, which appeared to be a specially suitable area for this purpose. Two foreign pines are present here, *P. ponderosa* and *P. arizonica* which were sown by Mr. H. G. Champion, Silviculturist, Forest Research Institute. The majority of these plants about 50 in number are *P. arizonica* which, like *chir* is also a 3-needled species ; all appeared healthy and none dying like the adjoining *chir*. The area all round this plot was well stocked with poles and mature trees and the nearest young regeneration was at a distance of about ½ a mile in compartment 5 and still further away in compartment 8[*]. These two compartments are separated from this experimental plot by a ridge which rises up to about 300 ft. or more and maintains more or less advanced pole stands from the slope up to the spur facing the infected plot from the north-east, the general aspect of Kaligadh being south-western. From the point of view of making a thorough search this isolated area was considered very suitable. It was observed during the previous tour, in May and June 1927, that the fungus had killed about 60 per cent. of the saplings, the remaining young plants appearing in a moribund condition and there being hardly any sapling which could be taken as free from infection.

Field work was started in October 1927. The monsoon rains being just over, the floor of the forest was thickly covered with various tall grasses, ferns and other herbs with frequent bushes of barberry, *Rubus* and *Cratægus*. In the ravine which formed the south-eastern boundary there were *Myrica nagi*, *Pyrus pashia*, *Ficus* spp., *Rosa moschata*, *Pieris ovalifolia* and a few other broad-leaved species. Closely associated with the grasses and ferns there were also species of *Swertia*, of which *S. alata* (Frontispiece) appeared to be the predominant one. These herbs appeared to be flourishing in this area and some of them has grown to a height about 2′-6″. The lower leaves, evidently the oldest, were noticed to be rotting, due to the attack of a rust fungus.

On examination it was found that these leaves were heavily covered by a rust whose telial columns were projecting from the lower surface of the blade like felty outgrowths. The infection on the leaves appeared to be in more or less roundish patches ⅛ to ½ of an inch in diameter and sometimes extending to almost the whole of the under surface of the leaves. The colour of these patches varied from orange and rusty brown (uredosori) to a mixture of pale rusty and dark brown (teleutosori).

Microscopic examination of the fungus in camp showed the rust to be a species of *Cronartium*. The uredostage in most of the leaves was almost over and the teleutocolumns were coming out from them. The small hair-like outgrowths which by their close association formed a felty mass on the leaves were really the innumerable teleutocolumns. The teleutospores were producing sporidia in profusion. The sporidia germinated in spring water, distilled water, and rain water and produced germ tubes in 12 hours.

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[*] This fungus has since spread to compartment 5 and specially to compartment 8 which contains a large amount of young growth on both sides of the spur. Infected *Swertia* plants were collected from the vicinity of the dead pines and from the fire-line during the inspection in October and November 1929.

This discovery led to a further search through most of the infected areas which were inspected during the previous summer and *Swertia* plants with *Cronartium* infection were collected from the compartments or in the neighbourhood wherever *Peridermium* had been observed on *P. longifolia* during the summer. At the same time it was also noted that this fungus was absent on *Swertias* in those blocks where the pine was yet free from infection.

The exotic 3-needle pines, *P. arizonica* and *P. ponderosa* which were growing side by side with *P. longifolia,* appeared to be entirely free from the attack of the stem rust. There was no other species of pine in the neighbourhood at Ranikhet. Blue Pine (*P. excelsa*) is occasionally planted in gardens in such hill stations in India so a thorough search was made for it in the Chaubatia gardens and plantations and in private compounds in Ranikhet in order to be quite certain that this infection on *Swertia* plants had not come from any stem Peridermium, other than *Peridermium himalayense.* But no such tree, not even a garden specimen, could be found at Ranikhet. About a dozen *P. excelsa* trees were noticed in the cantonment of Almora and 7 trees in Sitoli Forests, Almora. There was also a small plantation of *P. excelsa* in Banaik, China Range, Naini Tal. These plantations were thoroughly examined during the previous tours, in May, June and July 1927, and were inspected again in the following November for stem infection. But so far as the stem-form of blister rust was concerned, they were free from this disease. From these considerations the *Cronartium* on *Swertia* appeared to be significant and it was therefore proposed to carry out a detailed investigation to establish, by cross inoculation experiments, the biological relationship, if any, between the two forms. The result of this investigation is recorded in the following pages.

II. DISTRIBUTION OF *SWERTIA* IN THE HIMALAYAN AND SUB-HIMALAYAN FORESTS OF INDIA.

Swertia is a genus belonging to the family *Gentianaceae.* Some species are annual herbs while others are perennial. They contain a bitter principle and one species in particular, *Swertia chirata,* is used practically all over India as an indigenous medicine, more or less in the nature of a substitute for quinine, and is popularly known as " chirata." The decoction of this herb, especially of the leaves, is used as a preventive of malarial fever and in cases of liver complaints. Of the thirty species described by Hooker in the *Flora of British India* (13), five species, all of them sub-tropical annual herbs, were collected from the infected and uninfected pine compartments of the Almora and Naini Tal Divisions. In general the *Swertias* have a wide distribution which extends from the tropical to the alpine Himalayas. Some species occur frequently in the sub-tropical regions on the foot hills of the Himalayas (3,000 ft.-5,000 ft.) and in the Bhabar and Tarai. They are very common in the temperate Himalaya (6,000 ft.-8,000 ft.) and also spread into the Alpine Himalaya (8,000 ft.-10,000 ft.). The genus extends from the Karakorum ranges to Kashmir, Nepal and Bhotan as far as the far eastern ranges of Assam. It also occurs in the Deccan Peninsula chiefly in the hills of south west India.

The common species which the writer collected from the pine forests of Kumaon are the following :—

(1) *Swertia angustifolia* (Plate III),
(2) *S. purpurescens*,
(3) *S. cordata* (Plate IV, Fig. 4),
(4) *S. alata* (Frontispiece and Plates I & II) and
(5) *S. paniculata*.

Of these *S. angustifolia*, *S. purpurescens* and *S. cordata* are present everywhere in these forests of Kumaon, while *S. alata* and *S. paniculata* are less common. Their distribution in the pine forests, especially those of West Almora and Naini Tal Divisions, is generally localised. They form a rather dense growth in small shallow depressions just at the foot of a slope where water accumulates, or along the edge of the ravines covered by mosses and ferns but rarely in the ravine. They are sometimes found on nearly level ground and occasionally on the spurs of ridges. They may occur as small isolated colonies distributed over a large area and when growing on the edge of the cliff, overhanging a low-gradient slope they often appear as small colonies. The number of plants forming such colonies varies from a few to hundreds. They may occasionally grow interspersed with other annual herbs, when isolated groups of a few plants are found here and there.

III. FIELD STUDY OF INFECTION IN KUMAON AND GARHWAL FORESTS.

(a) Distribution of various species of Swertia in the infected pine forests and extent of Cronartium infection.—During the course of this investigation extensive areas of pine forests were searched in Kumaon for the alternate host of *Peridermium himalayense*. The following

blocks in which this search was conducted are described and the extent of pine infection indicated :—

Division.	Range.	Blocks.	Intensity of infection.
1. West Almora	1. Ranikhet	1. Kaligadh	****
		2. Padholi	†
		3. Ganeadeoli	†
	2. Cantonment	4. Cantonment	*
		5. Chaubattia	**
	3. Dwarahat	6. Kapoli	***
		7. Chakargaon	****
		8. Manila	†
	4. Almora	9. Kalimat	****
		10. Baldhoti	****
		11. Sitoli	**
		12. Simtola	***
		13. Chitai	**
		14. Ghurari	†
		15. Chaunsli	†
		16. Pakhura	***
		17. Matena	****
		18. Pharkanauli	*
	5. * Dewaldhar	19. Jaulkande	†
		20. Dhaulchina	†
		21. Girechina	†
		22. Maharpali	*
	6. Someswar	23. Garanath	**
		24. Airadeo	†
		25. Khajuri	†
		26. Pyakham	†
	7. Garkhet	27. Khabdoli South	****
		28. Majkot	*
		29. Bajgaon	†
2. Naini Tal	8. China	30. Benaik	**
		31. Sukha	****
		32. Nichna	****
	9. Bhowali	33. Bhowali	***
		34. Ninglat	***
		35. Gagar	**
		36. Sat Tal	**
		37. Maheshkhan	***
		38. Tani	*
	10. South Gaula	39. Patlot	†
	11. Manora	40. Loichusani	†
		41. Mongoli	†
		42. Ruinsi	†
3. Garhwal	12. Pindar	43. Pindar-Par	****
		44. Pindar-War	**
		45. Deosari	***
	13. Dhanpur	46. Dhanpur	***

Symbols of pine infection :—

****=very heavy,
*** =heavy,
** =moderate,
* =just starting or having only a few saplings infected here and there.
† =free.

It has already been mentioned in the introduction that *Cronartium*-infected *Swertia* was noted in all the pine infected areas and that where the pine appeared free from the rust the *Swertias* were also free.

The following list shows the distribution of various species of *Swertia* in the above mentioned blocks and the scale of *Cronartium* infection as based on field study :—

Host.	Division.	Range.	Blocks.	Intensity of infection.
1. *Swertia alata*, Roxb.	West Almora	Ranikhet	Kaligadh	****
		Almora	Pharkanauli	*
		Dwarahat	Chakargaon	****
	Naini Tal	China	Sukna, Nichna Benaik.	****
		Bhowali	Bhowali	**
			Ninglat	****
			Gagar, Tani	***
	Garhwal	Pindar	Pindar-Par	***
		Dhanpur	Dhanpur	***
2. *Swertia angustifolia*, Ham.	West Almora	Dwarahat	Chakargaon	****
		Almora	Kalimat, Matena, Pakhura.	****
			Chitai and Pharkanauli.	*
		Someswar	Garanath, Airadeo, Kajuri.	** †
			Pyakham.	*
		* Dewaldhar	Dewaldhar	†
			Maharpali	†
			Dhaulchina	†
			Girechina	†
			Jaulkande	*

Host.	Division.	Range.	Blocks.	Intensity of infection.
2. *Swertia angustifolia*, Ham.—*contd.*	West Almora .	Garkhet .	Khabdoli South .	****
	Naini Tal .	China . .	Sukha, Nichna, Benaik.	**
	Garhwal . .	Pindar . .	Pindar-Par and Deosari.	****
		Dhanpur .	Dhanpur . .	****
3. *Swertia cordata*, Wall.	West Almora .	Almora .	Kalimat, Matena .	**
		Someswar .	Garanath . .	**
		Dwarahat .	Manila . . .	†
	Naini Tal .	China . .	Sukha, Nichna .	**
	Garhwal . .	Pindar . .	Pindar-Par, Deosari .	**
4. *Swertia purpurescens*, Wall.	West Almora .	Almora .	Kalimat, Sitoli, Matena, Pakhura.	†
		* Dewaldhar .	Jaulkunde, Maharpali.	†
		Someswar .	Aredeo, Pyakham, Kajuri.	†
	Naini Tal .	China . .	Sukha, Nichna, Benaik.	
		Manora .	Mongoli, Ruinsi, Loichusani.	†
		South Gaula .	Patlot . . .	†
		Bhowali .	Gagar, Bhowali, Tani, Ninglat.	†
	Garhwal . .	Pindar . .	Pindar-Par, Deosari, Pindar-War.	†
5. *Swertia paniculata*, Wall.	West Almora .	Almora .	Chaunsali, Ghurari, Sitoli, Matena.	†
		* Dewaldhar .	Maharpali . .	†
	Naini Tal .	Bhowali .	Bhowali, Gagar, Tani.	†
		China . .	Benaik, Sukha, Nichna.	†

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* *N.B.*—The Dewaldhar Range has recently been abolished and the blocks are redistributed to Almora and Garkhet Ranges.

Scale of infection—

- (i) ****—on leaves, stem, flower-stalk, capsules, calyx-lobes, practically all over the green parts of the plant.
- (ii) ***—on leaves and stems.
- (iii) **—moderate infection of leaves only.
- (iv) *—Just a few small patches on one or two leaves which appear on a few plants.
- (v) †—no infection whatsoever.

From the above description of the diseased pine stands and the distribution of *Swertia* in the Kumaon and Garhwal *chir* forests it is reasonable to expect that in course of time this blister-rust will spread to those blocks which now appear to be free from this disease. The æcidiospores are carried a long distance by wind and other agencies and being protected by a thick wall they retain their viability for a considerable time. Infection of susceptible broad-leaved hosts is known to take place by such long-travelled spores under favourable atmospheric conditions. *S. angustifolia* may therefore be regarded as a source of danger to the young regeneration in the area where it grows. In fact, it is difficult to say with any degree of certainty that the blister-rust is definitely absent from any block of *chir* forest in Kumaon and Garhwal.

Towards the end of November it appeared that the *Swertia* plants were dying down. There was early frost all over these hills and snow fell on the China range and Benaik saddle by the middle of December. This change of weather perhaps brought the season of *Swertia* to an early close, but even then a careful search in the earlier part of December revealed the presence of the *Cronartium* fungus on the fallen leaves and leafless stems which were still to be seen here and there. By the end of December it was difficult to find any *Swertia* plants in the forests, the soft parts had completely decayed and only portions of their stems which were found standing here and there signified their presence in these forests earlier in the season.

(*b*) *The distribution and aspect of the infected Swertia-field with reference to the infected pines.*—The distance of the infected pine stands from the colonies of *Swertia* plants bearing *Cronartium* infection, which are referred to as "*Swertia-fields*" in the following pages, appeared to be a variable factor in different compartments. For instance, in Kaligadh compartment 2, Ranikhet, *Swertia alata* plants were interspersed with the infected saplings and some of them growing at a distance of one to three yards from the diseased pines. The case with the Kalimat compartments 1 and 3 was different. *S. angustifolia*, the important fungus-bearing species in this block, was growing on a small level field and the heavily infected plots of pine were lying on both sides of this *Swertia*-field at a distance of 30 and 70 yards. There were cases of isolated infection of pines here and there below the two spurs facing compartment 1 from a north and north-easterly direction and these may be related to small colonies of infected *S. angustifolia* consisting of a few plants which were found in the close vicinity of the diseased pines. In the same range in the Baldhoti, Simtola, Pakura and Matena blocks *S. angustifolia* infected with *Cronartium* was also noted in colonies consisting of 10-15 plants. They were growing within close range at a distance of 5-10 yards from the infected groups of pine.

The infected compartments of Khabdoli South, Garkhet range, *viz.*, 27, 28, 29 and 30, presented an interesting case from this point of view. The compartments have a general south-westerly aspect. Overlooking compartments 27 and 28 and partly 30 from the northern side there is a long ridge with a number of depressions or furrows dividing it into 6 or 7 small peaks. The relative elevation of these peaks from the forest path varied between 50 to 120 ft. This ridge is the water-shed between the Lahore and Gumti rivers and forms the fire-line separating the North and South Khabdoli blocks. Consequently it is burnt annually and is heavily grazed by cattle. Along this water-shed there were about 4 small fields teeming with *Swertia angustifolia.* These plants were heavily infected with *Cronartium.* Proceeding along the forest path, which divides the compartment 27, a gradual increase in the percentage of pine infection from 2 per cent. to 5 per cent. approximately was noticed, until a plot lying about the middle of compartment 28 was reached. In this plot the number of infected pines appeared to increase rather abruptly and the casualties were approximately 15 per cent. The situation of this plot was at a distance of about 30 yards in a south-easterly direction from one of the *Swertia*-fields. The next plot which showed a higher rate of mortality, approximately 22 per cent. was lying in a south-westerly direction and at a distance of about 50 yards from another field of *S. angustifolia.* The most heavily infected pine plot in this block was recorded covering partly compartments 28 and 30, *i.e.*, on the northern boundary where these two compartments meet. The blister-rust had taken a heavy toll, for about 30 per cent. of the young regeneration had already been killed and about 40 per cent. saplings bearing the æcidial fructification of the rust were doomed and the rest appeared in a moribund condition. It was difficult to say if any of the apparently healthy saplings were free from infection. These trees appeared to have received infection from two fields of infected *S. angustifolia*, one situated on the southern spur at the termination of the above-mentioned ridge and at a distance of about 65 yards from the middle of this pine stand and the other at a distance of about 80 yards from the same centre of disease. The young growth, consequently, appeared to be receiving infection of sporidia in a north-easterly direction from the first source and north-westerly direction from the second source, while the infection of *Swertia* might have taken place from the same æcidial source in the reverse direction, *i.e.*, from a south-westerly and south-easterly direction. Another field of *S. angustifolia* with a heavy *Cronartium* infection was noted on a small flat lying between compartments 29 and 30.

In the controlled-fire experimental plot of Phakranauli, Barechina block, Almora range, specimens of *S. alata* with *Cronartium* fungus as well as *S. purpurescens* without fungus were collected from the plot D which is subjected to controlled burning twice and from plot C which is burnt every year under control.

The isolated distribution of *S. angustifolia* in the heavily infected diseased pine forests was observed in the Chakargaon plantation in Dwarahat range, West Almora. Several gaps (Plate V) had been formed in this block due to the heavy mortality of the saplings and attempts to re-stock them by occasional sowings in patches have so far failed.

In Nichna block, Naini Tal division, *Swertia*-fields with heavy infection of *Cronartium* were noted on the fire line along a ridge on the north-western face of compartments 8 and 9, while in Sukha block the source of infection was seen to be spread all over the compartment. The species which bore the *Cronartium* stage were *S. alata* and *S. cordata* of which *S. alata* had a heavy infection of the fungus. In the Gagar (Shamkhet), Bhowali and Ninglat blocks, Bhowali range, Naini Tal division, *S. alata* was the only species noted with this fungus and was similarly distributed as in the Kaligadh compartments, Ranikhet, and the Sukha blocks of the China range, Naini Tal. In the Gagar blocks a small field of *S. alata* was noted in a shallow depression facing the pine-infected area from a north-westerly direction.

In the Garhwal division, so far as was inspected, the distribution of *Swertia* hosts in Pindar-Par, compartment 27, appeared rather scattered and *S. alata* and *S. angustifolia* were the main species. The pines were growing on steep slopes with a more or less south-westerly aspect. The broad-leaved hosts were found here and there in shady depressions at the foot of over-hanging rocks and also on the fire-line. In the Deosari regeneration area, compartment 11, the distribution of *S. angustifolia* was rather scattered, while in compartment 12 this species was noted as small fields in the depression at the foot of the north-eastern ridge forming the fire-line.

The direction of the prevailing wind in Kumaon and Garhwal during the months of June, July and August, *i.e.*, prior to and during the monsoon, when dissemination of æcidiospores takes place, is south and south-easterly, while during October and November, when the pine infection takes place, the direction of the wind changes to north-westerly. The topography of the land causes local variations, such as in the Almora range proper which does not get the north wind directly during the autumn and winter as it is protected by the higher range of Binsar. But in general, the above observations explain the wind dissemination of spores in those cases where the *Swertia* hosts appear in colonies either within or near the infected pine stands. In these forests the relation of two hosts with reference to direction or aspect is such as can be interpreted in the following lines. The wind borne æcidiospores are carried from the pines by the south-easterly wind during the rains and infect the *Swertia* plants which are generally found on the north-western slopes of pine forests, while in October and November the sporidia are carried from the *Swertia* to the pines by the north-westerly wind then prevailing. Where the *Swertia* plants are interspersed with the infected pines the infection takes place at close range, dissemination of spores taking place during the calmer weather helped by any slight breeze.

(*c*) *The relation between the dissemination of æcidiospores and the appearance of the uredostage on Swertia.*—A great deal of time was devoted to the study in the field of the relation between two important facts in the history of this disease, *viz.*, the gradual disappearance of the æcidial stage in late summer and early rains and the subsequent appearance of the uredostage on the *Swertia* host. The data available in course of the field study in June and July 1928 very strongly suggested the possible inter-relation of the two forms of the fungus—the æcidial stage on *Pinus longifolia* described previously as *Peridermium himalayense* and the *Cronartium* fungus on *Swertia* discovered in October 1927. The meteorological data available are unfortunately rather scanty in these ranges where pine infection had been studied, consequently the writer has had to depend on the reports from the stations where such data are kept. On receiving information that the monsoon had started on these hills the writer left Dehra Dun on the 7th June 1928 and went to these forests but found on arrival there that though the early monsoon showers had fallen proper monsoon conditions had not set in. There had been, in fact, several showers between the 4th and 10th June. From the night of the 5th till the 10th it had rained rather heavily at Ranikhet and Almora but this was broken by a dry period of about 2 weeks.

The inspection of Kaligadh compartment, Ranikhet, at the end of June showed that 17 saplings of pine had already shed all their spores. The æcidial sori had discharged the spores and the disintegrated peridia were partially eaten by insects. Bleached spores were, however, traced all over the crevices of the bark of the dead trees and a large number of spores were found lodged inside the bark in which the sori are generally embedded and in the base of the small pockets formed by the sori. These spores were mostly covered by the excreta of insects and to a great extent by exuded resin. When the resin covering was removed carefully it was found that some of these plastered up spores had retained their orange colouring and perhaps their viability. These were undoubtedly the spores from the early summer fructifications. There were 11 saplings just dying ; they bore a large number of yellow pustules which could be seen from a short distance. A closer examination of these specimens showed that though the early monsoon showers had disintegrated about 60 per cent. of the sori and had dislodged most of the spores from these sori, at least 15 per cent. of the fruit bodies still had the peridium intact. These dislodged spores, carried by rain, were deposited on the bark and appeared as streaks of orange-yellow all round the stems of the infected saplings, down to the base of the tree. The ground at the base of the tree was in some cases dusted with the orange-yellow spores. The sheaths and leaf blades of several species of grasses and the lower branches and leaves of dicotyledonous species growing close by the infected pines were also dusted with spores. *Swertia* was not noticed in Kaligadh compartment just at this time.

On the 2nd July, the Kalimat plantations, Almora, which are about 15 miles south-east of Ranikhet as the crow flies, were inspected. By that time three more moderate showers had fallen. In this area about 80 per cent. of the infected saplings, some of which had already died and others showing signs of dying were devoid of the æcidial pustules, the peridia having disintegrated and spores washed away. These trees presented the same pathological features as those of the Kaligadh compartment already described. The remaining 20 per cent. of the infected saplings which also appeared in a moribund state had a large number of these pustules in an unopened condition. But in cases where the peridium had become disintegrated and the spores discharged, a careful examination showed the sori to have retained a large number of spores apparently in a viable condition. Also a large number of spores lodged in the crevices of the bark of such infected saplings appeared as orange coloured streaks all over the stems.

The gradual progress of spore dissemination was studied for another three weeks during which rain fell in intermittent showers, till finally the monsoon broke and the writer was fully convinced that even though some continuous and heavy showers had fallen for sometime, it would be possible to detect by the end of August a large number of spores in an apparently viable condition at the base of the pustules. These spores would germinate by the end of July if favourable atmospheric conditions, *i.e.*, low temperature and humidity, prevailed. These are the conditions, as verified by inoculations in the following year, which are suited for natural infection. The dense mist which hangs over the forests in the later part of monsoon and cuts off the intensity of sunlight for hours and at the same time keeps the surface of the leaves of the *Swertia* hosts well sprayed with moisture is an important factor which favours the infection of this rust. By the third week of June *S. angustifolia* was noticed in Kalimat and by the 1st week of July *S. alata* was observed at Kaligadh. By the end of July *Swertia* plants had come out all over these forests in Kumaon.

Simultaneously with the gradual disappearance of the æcidial stage the appearance of the uredostage was noted. The first case of undoubted infection of the leaf of *S. cordata* was seen on the 4th July and that of *S. angustifolia* on the 6th July at Kalimat, Almora. By the middle of July as one got accustomed to it numerous cases of leaf infection were noticed. The pale spots on the leaf blades gradually extended and became raised and ultimately developed into uredosori This change was easily observed on *S. angustifolia* which was the most susceptible of the three species growing in Kalimat. After this the writer left the forests and the subsequent events of the succession of the uredo and telutostages were studied from specimens of infected *Swertia* received from the field weekly. The first teleutosori on *S. angustifolia* were noted from specimens collected by the middle of August. Specimens of *S. alata* showing the uredostage were received by the middle of July and these showing the teleutostage about the end of August.

IV. MORPHOLOGY OF *CRONARTIUM HIMALAYENSE* sp. nov.

(*a*) *The uredostage.*—The uredosori appear on the under-surface of the leaves as irregularly distributed round or circular patches, and finally spread on to the stems and calyces as close colonies of an orange-yellow to rusty yellow colour. They are 150 to 200 μ in diameter, and dehisce by a central pore which opens at the stomatal region at first but this opening gradually extends outwards owing to the pressure of the increased spore-formation, and, as the uredospores mature, the peridium is forced up into the dome (Plate XI, Figs. 1, 2, 3 and Plate XII, Figs. 1 and 2), resulting in the loss of the outline and regular shape of the peridial cells which become flattened and almost indistinguishable; peridium evanescent, delicate, colourless, cells elongated to obovoid 16·5×13·5 μ to 23·5×18·5 μ; uredospores orange-yellow in mass, ovoid or ellipsoid, 18·8×14·8 μ to 26·5×18·5 μ, averaging 22·5× 16·5 μ, wall light yellow to light orange, 2 to 3 μ thick, sparsely and sharply pointed (Plate XVI, figs. 6*a* and 6*b*). The uredospores were collected from the mature uredosori and were removed from the under-surface of the leaves by a fine brush and were examined while fresh from day to day in glycerine water. The average was taken from 1,200 measurements from 3 sets of spores, the larger, the medium and the smaller set, each set consisting of 400 spores.

(*b*) *The teleutostage.*—The teleutosori arise either from old uredosori or as entirely new and separate entities (Plate XIII, figs. 1 and 2 and Plates XIV and XV). In the former case the teleutocolumns are first produced from the central part of the uredosori and are surrounded by a region of cells which consists of disintegrated uredosori (Plate XIII, fig. 1). In the later case the development of the teleutocolumns starts from the central mass of hyphæ growing in the sub-stomatal vesicle of the infected leaves (Plate XIII, fig. 2). As the spore column lengthens the peridium is pushed up into a dome, which later on ruptures and goes to pieces. The fully developed mature spore columns appear as curved hairy growths on the under-surface of the leaves and finally on the stems and other green parts of the plant (Frontispiece, Plates I, II, III and IV). They have a walnut brown colour, size 450 ×50 μ to 800×85 μ, average length 750 μ and thickness 80 μ; spores light brown cylindrical to polyhedral or occasionally spindle-shaped (Plates XIII, XIV and XV). The teleutospores may touch one another, sometimes abutting on their neighbours, or they may be interspaced, corners rounded or obtuse at both ends, 27·2×12·6 μ to 39·5×18·5 μ, wall smooth, thickness ·08 to 2·5 μ. The spores mature from the centre outwards as noted by Colley (11) in the case of *Cronartium ribicola.* Most often those of the middle region germinate earlier than those forming the tip of the column. Sporidia delicate hyaline, globoid, 5·5 to 6·5 μ, germinating easily and producing germ-tubes (Plate XVI, figs. 5A, B and C) in 8 to 12 hours.

(*c*) *Succession of uredo and teleutostages.*—During the past three years of actual field study, the data for this line of investigation were collected from the experimental area at Kaligadh forest block, Ranikhet. The forests in this area being surrounded by hills on all sides retain sufficient moisture to keep the herbaceous *Swertia* host alive longer and being also sheltered from the north they keep warm till late autumn. This area therefore appeared very suitable for this purpose.

As in *Cronartium ribicola,* so with this fungus, there is generally a successive series of uredospore productions which are again followed by a similar series of teleutospore crops. In 1927 when this fungus was first noticed in Kaligadh seven series of uredospore crops were counted. This was succeeded by a mixed crop of both uredo and teleutospores till the end of October. In 1928 the succession of pure uredo-crops came to an end by the 2nd week of August and there were about 3 series of crops of this stage. In 1929 about 5 series of uredospore crops were noticed. From the point of view of weather conditions as will be shown in a succeeding chapter, the years 1927 and 1929 were favourable for the natural infection of *Swertia.* A pure uredostage is generally of short duration and terminates by the end of August or even earlier depending on the weather conditions. The uredostage may therefore be regarded as the repeating phase in the life cycle of the fungus the infection being carried from the infected to the uninfected leaves of the same species or of different species if the species is a susceptible one, till the warm summer condition changes.

As compared with the uredosori, the teleutosori are produced in relatively greater abundance with each succeeding generation. Up to six distinct waves of teleutospore crops were counted in 1927 and about three crops in 1928, while in 1929 four series of this crop were noticed in Kaligadh forest block, Ranikhet (Plate I).

The teleutospores germinate and produce at first a knobby outgrowth, the young promycelium, while attached to the leaves and other green parts of *Swertia* plants (Plate XVI, Fig. 1). In the course of further development this structure divides twice and ultimately produces a four-celled promycelium (Plate XVI, Fig. 2). Each cell of the promycelium germinates and produces an elongated structure, the sterigma, bearing a sporidium at the tip. The sporidia, when mature, are discharged and the promycelium collapses (Plate XVI, Fig. 3). The sporidia germinate frequently when moist weather prevails. If teleutocolumns are collected during a wet morning and examined under a microscope, one can easily observe mature sporidia germinating and sticking to the teleutocolumns. They can be germinated easily in a moist-chamber slide and successive stages in the development of germ-tube may be seen (Plate XVI, Figs. 5 A, B and C).

(*d*) *Technical description of the fungus.—Cronartium himalayense sp. nov*; *synonyms*, *Uredo opheliæ* Sydow (27), *Peridermium complanatum,* var. *corticola,* Barclay (5), *Peridermium himalayense,* Bagchee (3).—

Pycnidia caulicolous, under phelloderm, small, inconspicuous, scattered, forming minute blister-like swellings, exudation orange-yellow, mixed with resin or sweet fluid ; spores hyaline, colourless when single, light yellow in mass, ovoid to ellipsoid, averaging 4·2×2·5 μ.

I. *Aecidia* caulicolous, large, prominent, usually separate sori, on small branches elongated or short protuberating sacs, on trunks of trees occasionally confluent, 4 to 12 mm. long with 2 to 6 mm. diameter colour orange-yellow ; spores orange-yellow, obovoid to elliptical, averaging 24·7×17·4 μ, outer wall coarsely verrucose, epispore (including tubercules) measured from end view 3 to 3·75 μ, measured from side view 3·5 to 4·5 μ, *peridia* thick, persistent, multi-layered, 3 to 4-celled, ridged and furrowed on the top and finely grooved laterally, rupture by irregular fission along the lines of grooves and at right angles to them or by irregular cracks on the top of the dome, long and short dimensions measured from the middle of fully developed peridia averaging 27·9×18·2 μ, external wall of the outermost peridial cell including tubercles 5·2 μ ; filamentous outgrowths from the inner wall of the peridium, length 2 to 4·5 mm.

On *Pinus longifolia.*

II. *Uredosori* hypophyllous, spreading on to the stem and other green parts, scattered to sub-gregarious, hemispherical, colour orange-yellow to rusty-yellow, 150 to 200 μ in diameter, dehiscent by a central pore which opens from the stomatal region at first and finally extends outwards ; *peridium* evanescent, delicate almost indistinguishable in mature sori, cells elongated to obovoid averaging 20·5×14·5 μ ; spores orange-yellow in mass, ovoid or ellipsoid, averaging 22·5×16·5 μ, wall light yellow to light orange, 2 to 3 μ thick, sparsely and sharply pointed.

III. *Teleutosori* hypophyllous, finally spreading on to stem and all green parts of plants, cylindric, 750 μ long, 80 μ thick, colour walnut brown ; spores light brown, cylindrical to polyhedral or occasionally spindle-shaped, corners rounded or obtuse at both ends, averaging 37·5×18·5 μ, wall smooth, thickness ·08 to 2·5 μ ; sporidia delicate, hyaline, globoid, 5·5 to 6·5 μ.

On *Swertia* spp.

Swertia alata, Roxb. West Almora, East Almora, Naini Tal, Garhwal and Chakrata divisions and the Mussoorie hills.

Swertia angustifolia, Ham. West Almora, East Almora, Naini Tal and Garhwal divisions and the Mussoorie hills.

Swertia cordata, Wall. West Almora, Naini Tal, Garhwal and Bashahr divisions and the Mussoorie hills.

The uredostage of this fungus was previously described by Sydow (27) as *Uredo opheliæ.* The genus *Ophelia* (of the family *Gentianaceae*) has been reduced to a sub-genus of *Swertia* (13). The complete stages of the fungus or its biological relationship with the pine rust have not been described before. It is therefore proposed to rename it *Cronartium himalayense* sp. nov. to be in uniformity with the æcidial stage which has been described as *Peridermium himalayense* (3).

V. EXPERIMENTS ON GERMINATION OF *SWERTIA* SEEDS.

The five species of *Swertia* which have been dealt with in this investigation have already been described as annual herbs. They appear in the forests during the early monsoon and die off entirely by the end of autumn or early winter according to the aspect and locality in which they grow, leaving their seeds in the grass and on the moss covered floor of the pine forest to re-appear next season when conditions become suitable for germination. For the purpose of cross inoculation experiments it was considered essential that the plants should be grown under control in a place far from the infected pine stands. The seeds were collected from various ranges of Almora and Naini Tal divisions and from as many compartments as possible, both from infected plants and from uninfected plants, and they were put in separate bottles. The size of the seeds varies. They are very small, approximately 1 mm.×$\frac{3}{4}$ mm.

The places selected for these experiments in 1928 were Dehra Dun (elevation 2,000—2,200 ft.) under semi-tropical conditions and Mussoorie (elevation 6,000—7,000 ft.) under temperate conditions. This latter place is 22 miles from Dehra Dun and within easy reach by motor-road. The first sowing of seeds was done on the 6th February in fine washed sand moistened with (i) distilled water, (ii) Knop's solution $\frac{1}{2}$ and (iii) $\frac{1}{4}$ strength, and (iv) in ordinary tap water. On the same day a second set of sowing was done in (v) a mixture of leaf mould and fine garden soil and (vi) in leaf mould and fine washed sand mixtures. There were two sets of each medium, one set was taken to Mussoorie and the other left at Dehra Dun. The sowings were repeated again at intervals of two weeks till the 6th of April, each time all the above media being used, and the result was awaited. There was no germination at all.

The second attempt to germinate the seeds was made about the middle of May and as before the experiments were repeated using all the above media. This time about 2 per cent of the seeds germinated but all of them perished due to heat and dry weather prevailing at both the stations.

The third attempt was made about the middle of June and this time about 3 per cent of the seeds germinated. Those at Dehra Dun perished due to the heat and dry weather whereas a lot at Mussoorie survived but remained in very poor condition.

The fourth set was sown three weeks later, on the 10th July, and this time soil from the forest of Almora and Ranikhet was used for the culture. The result was still better and about 5 per cent of the seeds germinated. It took about 15 days for the maximum number of seeds to germinate. By this time there were several showers which brought down the temperature and humid conditions prevailed. The seedlings survived, but their growth was very poor and the seedlings maintained only 2 pairs of leaves throughout their life. Those sown at Mussoorie started germination by the middle of June. Germination was however poor and the seedlings remained in a dwarf form with only 2 pairs of leaves. An attempt was made to inoculate them, but they soon perished naturally.

While the above experiments were in progress field observations were made to note the time when *Swertia* appear in the forests. Inspection at Kalimat showed that by the end of June the *Swertia* seedlings had just come out and that *S. cordata* and *S. purpurescens* were the two species which appeared early in the season. They were growing in small shallow depressions covered with moss and in places where some amount of moisture had been retained. There was no germination on the ridges and slopes even then. After a careful search all over the compartments for four days, from 28th June till 2nd July, the writer collected 27 seedlings of *S. cordata* about ½ inch to 3 inches high and 36 seedlings of *S. purpurescens* 1 inch to 6 inches high. *S. angustifolia* was noticed one week later. By the third week of July all the three species came out profusely and they gradually covered the places where they were recorded during the month of October in the previous year.

In Kaligadh, Ranikhet, a few seedlings of *S. alata* were noticed by the second week of July and a good many of them were visible within a fortnight after. The year under consideration was abnormally dry and the monsoon was later by about 10 days than is usual in the Kumaon hills. By the first week of July the monsoon started in full swing. The rain continued for days with occasional breaks, sometimes a heavy downpour being followed by a drizzle, a phenomenon common during these rains. The atmosphere was saturated with moisture and during the interval when the rain stopped mist and fog covered the vegetation. This kind of weather continued practically till the end of August.

It appears from the above experiments that there is a long post-maturing period for these seeds and that of the seeds that are produced hardly 7 per cent germinate in nature, the rest being sterile. These facts were further supported when the germination experiments were repeated the next year in Almora and when attempts were made to raise the *Swertia* plants for inoculation experiments in the locality where they naturally grew.

In the following year, 1929, the 5 species of *Swertia* common in the pine forests of Kumaon, as mentioned previously, were raised artificially. From the experience of the previous year's field observations and germination experiments, it was known that the earliest crops of *Swertia* were found growing through moss beds in shallow depressions of the forests and that the moisture for such process was supplied by the occasional light showers of early June and the heavy night dew which falls on the hills in the summer months. A different method was therefore adopted for germination experiments in the following year. The place selected for this purpose was in the compound of Circuit House, Almora, which is about 2 miles from the infected pine stands of Kalimat. Small seed beds were made with a slightly shallow depression and a thin dressing of moss covering was given to these beds to simulate the natural beds of the forests but they were not watered at all. At the same time germination boxes filled up with the soil of the forests and treated with the moss-dressings in a similar way were set up. The boxes were watered twice daily from the 1st May till the middle of June when the early showers of the monsoon had fallen. This was done to force if possible early germination. Profuse germination in the boxes was noticed 10 days later. The moss cover not only helped germination but also supplied the necessary moisture to further the growth of the young seedlings. Of the five species, *S. purpurescens, S. cordata* and *S. paniculata* germinated well and grew to the proper size in the time calculated for inoculation experiments. But *S. alata* and *S. angustifolia* made very slow progress after germination. They appeared to be about 4 weeks behind the time they naturally come out in the forests, *i.e.*, when the seedlings in the forests were about 3 to 9 inches with 12 to 20 pairs of leaves, the artificially raised plants were only 2 to 4 inches and with 4 to 6 pairs of leaves. While the seeds which were sown in the beds were still later in germinating. They were just visible by the 7th of July. The monsoon rains started a little early that year and the *Swertia* plants appeared in the field about the 10th of June and by the end of the month some of them grew 3 to 6 inches in height. For the purpose of inoculation experiments the writer had to depend on a supply of *S. alata* from the forests.

VI. INOCULATION EXPERIMENTS OF *PERIDERMIUM HIMALAYENSE* ON *SWERTIA*.

(*a*) *Methods of inoculating Swertia.*—After two years of trial when the æcidiospore of *Peridermium himalayense* was successfully germinated

(Plate XVI, figs. 4^a and 4^b) and the approximate conditions of moisture and temperature were known, it was finally decided to conduct inoculation experiments to prove the biological relationship of the two forms.

Inoculations were done on the above-mentioned five Kumaon species of *Swertia* and the seedlings were selected, except in case of *S. alata*, from those grown in the compound of the Circuit House Bungalow, Almora, which is about 2 miles direct from the nearest infected pine area known, *viz.*, Kalimat. The seedlings of *S. alata* were transplanted from the forests of Barechina, and were kept under observation for 3 weeks. When they were established well in pots, they were again kept inside the inoculation chambers for another week and were afterwards used for experimental purposes.

Air-controlled chambers of size 3×2×2 ft. with glass panels and a small door to introduce the potted seedlings were constructed to conduct these experiments. Each chamber had a small hinged trap-door on the top panel, made of a fine-meshed wire-gauze. During each experiment a layer of sterilized gauze cotton wadding was placed on this wire-gauze, so that when this fly-panel was left open only air free from any spores in suspension could enter the chamber. Each chamber was completely covered from the top to bottom with a linen covering. A wash basin filled with water was placed on the top of the chamber and one end of the linen covering was dipped in the basin. The water flowing down the linen-tent, kept the glass panels wet and reduced the temperature inside the inoculation chambers. The basins were filled up with water once every 2 to 3 hours during the day and 3 to 4 hours during the night, depending on the surface evaporation. The effect of this contrivance was two-fold ;—a safe-guard from natural infection by entry of spores in the air ; and secondly, it worked like Hunt's iceless refrigerator (15) in bringing down the temperature of the chamber considerably. By this method an average of about 4° below the outside shade temperature was obtained. In fact, during the subsequent inoculation experiments with uredospore, the glass-chambers not being portable in these hills were discarded and rectangular wooden frames were used instead as supports for the wash-basin and the linen covers. This had the advantage of cooling as well as of keeping the air inside saturated with moisture, though not a safe device for accidental infection of spores in air suspension. In the former case another small basin filled with sterilised water was placed inside the chamber and a " flit-sprayer " was used at regular intervals for spraying the plants with sterilised rain-water.

The chambers were first disinfected with formalin vapour for 24 hours after which the top of the fly-door was opened and the chamber was kept in direct sunlight for 6 hours. The chambers were taken indoors and the *Swertia* pots were introduced. The chambers for inoculated plants were kept in one room while those containing the control plants were placed in another room at the furthest end of the house. Each set consisted of 3 pots and each pot with 3 seedlings for the inoculated sets and one pot for the control. They were kept inside the chamber for 24, 36, 48 and 72 hours. At the termination of the experiments some of the inoculated plants were taken to and isolated at the Divisional Forest Officer's bungalow, West Almora, at a distance of about 4 furlongs, while others were isolated in a closed bathroom of the Circuit House and the controls were placed in the verandah situated in the furthest wing from it. The chambers were disinfected and aired as before and the next set was placed inside after two days.

The inoculating material (æcidial sori) was collected at different dates on sunny days when the moisture on the trees had dried up and was always kept under dry conditions in stoppered vials ; the vials were stored in a refrigerator or in cool shady places under trees under the various conditions described subsequently under germination and longevity tests of spores. Inoculations with æcidiospores were done by the following methods as described by Spaulding, Hahn, York and others (24, 14, 32).

(i) The peridia were torn apart and the spores were dropped in rain water on a watch-glass and the *Swertia* leaves were dipped in this mixture giving as thorough and uniform a covering of the inoculum on the lower surface of the leaves as possible.

(ii) A mixture of the spores in rain water was sprayed on the leaves by an atomiser.

(iii) A mixture of the spores in rain water was painted on the lower surface of the leaves with a brush.

(iv) A mixture of inoculum and rain water was painted on the under-surface of the leaves with lancet-needles, scalpels, etc.

(v) The leaves were sprayed with rain water and a pine twig with open pustules was shaken inside the chamber, giving thereby a shower of spore dust.

(vi) Infected twigs with open pustules were placed inside the inoculation chamber, without shaking, with the *Swertia* plants sprayed previously with rain water.

(vii) Spores were germinated in rain water on moist chamber slides and were removed with a fine brush and the inoculum was painted on the under-surface of the *Swertia* leaves previously sprayed with rain water.

The methods (i), (ii), (iii) and (v) appeared very effective, though a liberal amount of spores was required for such experiments. But those plants which were given a very heavy dose of inoculum died off soon after producing uredosori while others with a slightly smaller dose remained in a moribund condition for some time and the leaves were killed soon after the appearance of the uredostage, the plants ultimately dying off. But those leaves which had a moderate amount of inoculating material developed the uredostage earlier and survived till the teleutostage appeared between September and October.

The Petri dish method of inoculating *Swertia* leaves, as suggested by Clinton and McCormick (9) was also tried but did not prove successful; the leaves of *Swertia* being very delicate, they withered away as soon as they were removed from the stem.

As noted by the European investigators on *Cronartium ribicola* (8, 9, 10, 11, 12, 14, 16, 17, 24, 26) only the leaves of moderate development took infection, those that were too young or too old did not produce uredosori. It was particularly noticed that the pair of cotyledonary leaves and two pairs of leaves following them and also those forming unopened or newly opened leaves appeared immune under all conditions while the experiments were being carried out. These facts were also corroborated by those of the naturally infected *Swertia* leaves during the field investigations.

While the above experiments on the inoculation of the æcidiospores were being carried on indoors, similar though not so completely controlled experiments were also being conducted at the same time in the field by placing potted seedlings of *Swertia* close to the heavily-infected pine discharging spores. Controlled plants previously covered by incubation chambers were transported to and maintained in the forests. These chambers were placed near the same infected tree along with potted plants which were exposed to infection and at an equal distance. This experiment was done in the infected plantation of Kalimat, Almora. At Dinapani Forest Rest House, an infected sapling with numerous æcidial sori in open condition was cut at the collar and was planted in a pot. The potted seedlings of *Swertia* were placed near this pine branch and the control plants in the chamber as in the previous case. Successful infection of *Swertia* was produced in both cases on the *Swertia* plants thus exposed while the control plants were free.

The uredospores germinated freely in rain water, spring water and distilled water (Plate XVI, figs. 6^a and 6^b). The most successful method of uredospore inoculation was by rubbing the uninfected *Swertia* leaves previously sprayed with rain water against leaves well covered with viable spores. The uredo inoculations were done out of doors and without the help of an inoculation chamber, in August 1928, at Mussoorie, with successful results. In 1929 this experiment was repeated and inoculations on *Swertia* were done inside the chambers under controlled conditions at Almora, from the 28th June onwards when inoculating material was not so profuse and within two weeks a series of uredosori was produced. Again in October, in the same year, when profuse uredospores were available, further inoculation of *Swertia* with this kind of spore was done at Ranikhet under linen moisture chambers of the type described above. This time also the writer succeeded in repeating the uredostage as transition-sori, which soon passed over to the teleutostage as the temperature came down.

(*b*) *Factors controlling successful inoculations.*—The factors primarily responsible for successful inoculation may be grouped under four headings, *viz.*, (i) humidity, (ii) temperature, (iii) light and (iv) condition of the leaves of the *Swertia* host at the time of inoculation.

(i) A high relative humidity close to saturation point was maintained throughout the infection period. The plants were finely sprayed with rain water with a " flit-sprayer " before they were placed within the inoculation chambers. They were frequently sprayed at the interval of one hour with sterilised rain water and a flat dish containing sterilised water was also put inside the chamber. After the inoculated plants were removed from the chamber they were placed inside a closed bathroom with sufficient moisture about, and sprayed frequently with rain water. The watering was sufficient to carry the infected plants to the sporulating stage.

(ii) Inoculations were done when the temperature of the incubation chamber was maintained between 60°-64° F. A continuous flow of water from the water basin on the top of the chamber over the wet tent-like cloth covering kept the plants within at a reduced temperature due to surface evaporation.

(iii) The maximum amount of infection was produced when the chambers were kept in the shade. From the point of view of reducing temperature a weak and diffused sunlight with sufficient air currents which helped in increasing surface evaporation seemed essential. When the plants were removed from the inoculation chamber, some sunlight through the glass panes of the ventilator proved helpful in bringing the incubation period to the minimum, but the complete absence of sunlight on the other hand was a favourable factor for the formation of mildew, which at times was very troublesome, as mildewed leaves rarely became infected.

(iv) The age of the leaves inoculated is an important factor on which successful inoculation depends. For this purpose freshly developed, fully expanded and unhardened leaves were selected. The plants inoculated were mostly seedlings with 8 to 20 pairs of leaves. Naturally, one has here again to guard against inoculating too young or too mature leaves. The choice was therefore limited. Most often two lower pairs and four upper pairs of leaves were left and those of medium development were inoculated. As the stomata of the leaves are the channels of entry of the fungus, flaccid leaves, or leaves which were injured were cut off, also plants which did not fully recover from wilting due to transplanting were rejected.

VII. PATHOLOGICAL STUDY OF INFECTION.

(*a*) *Penetration and histology of infection.*—The writer had entirely to rely on histological methods for the study of the penetration of the rust in *Swertia* leaves. Direct microscopic observation of the inoculated leaves was of no practical use for this purpose. The material was fixed from the inoculated specimens which were fortunately plentiful. The infection was apparent on the two susceptible species of *Swertia* within 8 days after inoculation. Consequently as the experiment proceeded the material was pickled at an interval of two days and the various stages from penetration up to the development of mature uredo and teleutosori were studied.

For the purpose of histological studies, material fixed in a chromo-acetic solution of medium strength, acetic-alcohol and formol-alcohol according to Colley's formula being used. Chromo-acetic of medium strength proved quite satisfactory. The material was passed through various grades of alcohol, cleared in cedar-wood oil and embedded in paraffin. The sections were stained in Heidenhain's iron-alum hematoxylin with a counter stain of orange G in clove oil. Breinl's stain (safranin and polychrome methylene blue) was also used.

The earliest stage during the process of infection was noted from the specimens when pale spots were just apparent on the leaves. A section of the leaves showing this stage is illustrated in fig. 1, Plate XI. An interesting point noted from a number of sections showing this stage is that the first mycelial tangle is always visible in the air-space below the stomata or in other words in the sub-stomatal vesicle The second point of importance which drew the writer's notice is the presence of haustoria-like hyphæ (*a*) fig. 1, Plate XI, just below the stomata. These structures are only seen at the earliest stage of infection. In one section, this later type of hyphæ was found in actual connection with the branching germ-tube of the æcidiospore. There is, therefore, hardly any doubt that the stomata are the channels of entry through which the germ-tubes of the æcidiospores enter the *Swertia* leaves and also the early branches of the germ-tubes of this species of rust has a marked haustoria-like character.

The formation of the uredo and teleutosori in *Cronartium himalayense* takes place more or less in the same way as that of the other *Cronartiums* so far investigated (11). The writer does not, therefore, propose to repeat the description of the successive stages in connection with this fungus. The figures 1, 2 and 3, Plate XI, figs. 1 and 2, Plate XII, figs. 1 and 2, Plate XIII and Plates XIV and XV, illustrate the general plan of the formation of the sori and the legends of the figures explain the successive stages.

The æcidiospores are binucleate. The hyphæ in the sub-stomatal vesicle resulting from the germination of the æcidiospores are also binucleate (Figs. 1, 2 and 3, Plate XI). This binucleate condition is maintained throughout the uredostage (figs. 1 and 2, Plate XII) and up to the young teleutostage (figs. 1 and 2, Plate XIII) but stages in which nuclear fusion was in process were noticed in the advanced teleutospore (fig. 2, Plate XIII and Plate XV). Subsequent changes in the nuclear elements during union and reduction in the promycelium, as described by Colley (11) and others, being a matter of detail and not exactly within the scope of this paper have been left out.

(*b*) *The inoculation period of Cronartium himalayense on Swertia.*— The incubation period of *Cronartium himalayense*, generally speaking varies from seven days to three weeks for all the species of *Swertia* concerned. It was not possible to determine the exact time when the leaves of the different species showed the first symptoms of infection under the condition under which the experiments were conducted, but the writer has no doubt that there is a range of incubation period on the different species of *Swertia* described as susceptible. The appearance of pale spots, which are considered the first sign of successful inoculation, was noticed on the leaves of *Swertia angustifolia* between 6 to 8 days after inoculation. These spots appeared slightly raised from the leaf-surface within a day or two and finally the uredosori were detected as early as the 9th day and by the 14th day most of the leaves inoculated bore uredosori. In case of *Swertia alata* the pale spots were noticed from the 13th to 15th day and the uredosori were noticed 16 days after inoculation.

Sixty plants of each of the above two species of *Swertia* were inoculated. The total number of leaves of *Swertia angustifolia* inoculated was

850 and of *Swertia alata* 650. Forty plants of *Swertia cordata* carrying 324 leaves of moderate development were inoculated. For every three pots each with three plants for inoculation there was one pot with three plants in the controlled chamber. The results are tabulated as follows :—

Species.	No. of leaves inoculated.	Ratio of leaf surface from the average of 100 measurements.	Percentage of leaf infection.	Average number of spots on each leaf.	Appearance of pale spots.	Appearance of uredo-sori.
			Per cent.			
S. angustifolia . .	850	1	98	9·5	6 to 8 days.	9 to 14 days.
S. alata . . .	650	2·9	85	7	13 to 15 days.	17 to 20 days.
S. cordata . . .	324	1·8	3	·058	11 to 14 days.	13 to 15 days.

(*c*) *Distribution and size of the sori of Cronartium himalayense on various species of Swertia.*—The uredostage appeared on *S. angustifolia* as isolated colonies or small patches irregularly distributed on the under surface of the leaves and gradually extended all over the leaf within a few weeks. Finally, the infection covered practically three-fourths of the lower surface of the leaves. When this stage passed on to the teleutostage during the advance of the season, the teleutocolumns naturally appeared as a uniform felt-like mass on the leaf area. The teleutocolumns appeared all over the green parts of this species in regular and uniform fashion from the base of the stem up to the calyces and flower-stalks (Plate III).

The distribution of this fungus on *S. alata* is of more localised character (Frontispiece). In fact, it was never noticed that the whole leaf surface was uniformly covered by it as in the case of *S. angustifolia*. Stem infection was also common on this species, but was confined only to that portion of the stem close to the leaf insertion. A few calyces were also noticed to bear the teleutocolumns, but only isolated sori were seen.

On *S. cordata*, the distribution of the sori was still more limited. Only a few patches of uredosori were seen here and there on the leaves. Most of the uredosori produced by the inoculation experiments died away and produced necrotic areas and occasionally shot-holes of the size of a small pinhead. While the uredosori produced by natural infection developed a few teleutocolumns later in the season as in the case of artificially inoculated *S. alata* plants.

The following measurements show a certain variation of the size of the uredo and teleutosori of *Cronarium himalayense* on three different species of *Swertia* ; the average is of 500 measurements, the specimens being taken from materials preserved in a 50 per cent. glycerine and alcohol mixture.

Host.	UREDOSORI (IN SECTION).		TELEUTOSORI.	
	Height.	Width.	Length.	Thickness.
S. alata	120μ	170μ	700μ	90μ
S. angustifolia . . .	112μ	150μ	790μ	85μ
S. cordata	94μ	145μ	650μ	60μ

(*d*) *The longevity of the spores and the "effective range"* of spore dissemination.*—The viability of the æcidiospores of *Peridermium himalayense* appeared erratic during germination experiments. All attempts to germinate them in various media during the previous years had failed. Attempts by the writer to germinate them in the months of May and June 1927, when various media were used such as rain water, cold and boiled decoctions of pine needles, spring water, distilled water, etc., were also unsuccessful. In June 1928, the writer used a cold decoction of *Swertia* leaves in rain water, when a few spores produced a small knob-like growth at the spot where they were attached to the intercalary cells and where the spore wall is practically free from warts. The knobs slightly enlarged into small protruding bodies and appeared pale orange to hyaline. Later on the spores became bacterially contaminated and degenerated. Further attempts were made from June 1929 when portions of fresh *Swertia* leaves were cut into circular discs and were placed in the depression of a moist chamber slide with the lower surface turned upwards and slightly moistened with rain water and spores were dusted on these leaves. The slides were in turn placed on a moist blotting paper inside a Petri dish and these Petri dishes were kept in iceless refrigerators which had been arranged for these inoculation experiments. By this method by the middle of July when the temperature of the refrigerator was between 60°-64°F., germination occurred but it was even less than 2 per cent. Later on the spores also germinated on slides the surface of which was moistened with a film of rain water but the spring water and tap water being alkaline in reaction were found distinctly harmful for such processes. Distilled water was also used with much less success. As noted by Colley, Spaulding and his co-workers, Klebahn and others

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* The writer is indebted to Dr. Spaulding (25) for the use of this term.

(11, 12, 14, 16, 17), it was observed that an excess of water proved inimical to germination.

The following experiments were done in order to ascertain the longevity of the æcidiospores.

(1) A series of experiments were conducted at intervals of 7 to 15 days in 1928 and 1929 under temperate conditions at Almora and Mussoorie and semi-tropical conditions at Dehra Dun, to germinate the æcidiospores from pustules which had been stored intact in a dry condition in stoppered vials from April to August, but these met with no success.

(ii) Specimens were collected from the 24th May up till the 16th July 1929 at intervals of 7 days from various ranges of the Almora division during the tour and were stored in three sets in stoppered vials and in paper bags lined with drying paper. One set was stored in the refrigerator (24°C.-28°C.), the second set was kept indoors on a table facing a window, the room temperature being 62°-68°F. and the third set was left under the shade of a tree (66°-72°F.). As before the pustules were left intact and the spores were removed by a needle. Germination tests were done from the 24th June up to the 16th July as already stated. The maximum germination was noticed from the lots which were collected between the 24th June to the 13th July and from those specimens which were stored in the refrigerator, while those which were collected after the 15th July when there was frequent rainfall soon got mouldy and did not keep well under storage conditions.

It is difficult to say how long the æcidiospores retain their viability in nature as the writer has no further experimental data on this subject. The result of field observations show that in the crevices of the bark of pine and in the base of the pustules which are generally embedded in the bark of the tree and are sheltered from rain and sun the spores retain their orange yellow colour. A percentage of these spores may retain their viability and continue to infect the young *Swertias* till the end of the rains. From the daily variations of temperature in these forests during the months of September and October and the other inclement factors to which they are exposed, *viz.*, occasional rain followed by strong sunshine, it is difficult to believe that the æcidiospores will retain their viability for any considerable time after the month of August.

The "effective range" of spore dissemination is at present under investigation and this subject will be a matter of future discussion when sufficient data have been collected, but from the observations of forest officers it appears to be fixed at about 2 to 3 miles according to the situation and aspect of the infected pine stands. This has been based partly on the information available on this subject from work done in European countries on the white pine blister rust and partly on the experience of the writer from his actual field study.

Specimens of *Swertia alata* and *S. angustifolia* with abundant uredosori were collected from the 12th July onwards till the 31st August 1928 and were stored in stoppered vials, in Petri dishes and inside paper bags lined with drying paper. *Swertia* plants collected from Ranikhet and Almora forests were transplanted in pots and afterwards transported to Mussoorie where they were kept under observation for 4 weeks to note if they were free from natural infection. After the maximum incubation period was over inoculation experiments were done with uredospores. Germination tests of uredospores, which were collected at various dates between the 12th July to the 31st August, were also made at the same time at an interval of 4 days in different media, *viz.*, distilled water, rain water, spring water, etc., which were also used during various attempts to germinate the æcidiospores. The best germination was noted between from 4 to 9 days after the collection of the specimens when about 5 per cent. of the spores germinated and so far as their viability was concerned the rate of infection practically coincided with the germination maximum. These experiments were repeated again from the 5th till the 16th July and from the 5th October till the 30th November 1929. This time the results differed. The inoculum collected in July had poor germination and the maximum germination was about 2 per cent. while those collected in September germinated better, about 7 per cent. having germinated by the second week of September. The maximum amount of infection took place from specimens which were collected between the 10th and 16th September and between 3 to 7 days after the specimens were collected and stored. After the 10th day the percentage of germination gradually fell off and no infection took place when the inoculum from 3-week old specimens was used. After the 2nd week of October the uredosori were becoming less and less every week and by the end of November no further supply of uredospores was available. Germination tests were done of the uredospores which were kept under storage conditions from the 16th to the 22nd December 1927 and from the 18th to the 24th January 1928, from the specimens which were collected on the 10th October and were kept under air-dried conditions in loose drying paper which is ordinarily used for drying botanical specimens and also in Petri dishes, but without any result. It appears from the above experiments that the uredospores do not retain their viability for long after the specimens are collected. The maximum germinating capacity and viability were found between the months of August and September when a large infection of *Swertia* by the uredospores takes place. Towards the end of October the uredosori became fewer as the teleutocolumns came out and in November they were rare and were only found on *Swertia* growing in warm and sheltered places.

Specimens of leaves with profuse and newly matured teleutocolumns were collected from the first week of September till the middle of December 1927 at intervals of one week and were kept in Petri dishes on dry blotting paper and were loosely covered by another dry blotting paper and weekly germination tests were done by removing some of the specimens to moist chambers. The maximum germination was noted between from 12 to 20 hours from the time when these leaves were collected from the *Swertia* plants. At the end of one week a few sporidia were produced and after 10 days the teleutospores failed to germinate and produce sporidia under these conditions, while those on leaves which were not removed from the plants and kept in the open at night in dew and stored in a cool place in shade during the day, germinated and produced sporidia till the end of the third week after they were stored.

The teleutocolumns are very fragile and even a gentle movement of the plants is enough to dislodge many mature teleutocolumns. These are cells which have mostly germinated and in fact represent the empty shells. They fall off more rapidly from the leaf attachment than the ungerminated ones. They were caught at a distance of 15 to 20 yards from the *Swertia* fields during the spore catching experiments. The teleutospores thus distributed did not germinate. They germinate *in situ* and produce sporidia.

The sporidia attached to the teleutocolumns were kept in a dry condition in the depression of a moist chamber slide which is generally used for hanging drop cultures and were covered by a cover-glass. The sporidia were removed by fine brushes from teleutocolumns and germination tests were done at an interval of 6 hours, when some of them were removed at intervals of 6 hours to hanging drop cultures of dew water from a cover-glass. The percentage of germination rose to about 8 per cent. in 24 hours and after 30 hours this was reduced to about 2 per cent. About 60 per cent. of these sporidia were undoubtedly immature when they were removed from the teleutocolumns and this fact should be taken into account.

The range of dissemination of the uredospores and sporidia were tested by various methods, *e.g.*, by using moist sheet glass, glass slides, Petri dishes, moist chamber basins and shallow glass basins partially filled with water. The moist glass plates and containers were placed on alternate days from the 20th October till the 15th December 1927 at different places in the infected *Swertia* fields and at various distances from these plants. These observations were repeated again in 1929 from time to time from the 6th October till the 10th December during the course of field study. But no reliable data could be procured at the termination of these experiments. The observations differed in different ranges owing to various factors controlling the distribution of the spores. The aspect of these forests and also the position of the *Swertia* fields with reference to the infected pine stands varied in different ranges as has been already noted before. It may also be said in this connection that there is no fixed direction in which the spores may be distributed for any considerable time. The direction of the wind as already stated is generally north-westerly but it changes occasionally to a north-easterly direction. The velocity of the wind varies between 5 to 20 miles per hour. But in all probability this may not represent the actual range which in some cases may be about double this rate. When calmer air prevailed the uredospores were collected at a distance of about 6 yards from the infected *Swertia*.

A remarkable fact which strikes one is the amount of teleutocolumns produced on the *Swertia* host which may be growing all over the infected pine forest or may be distributed in large colonies or isolated patches or in groups here and there. There could hardly be any doubt that when the weather is favourable the pine needles catch hundreds of sporidia from these infected *Swertia* at close range and during all hours of the day and night. The problem of " effective range " of dispersal of these 3 kinds of spores will be a subject of much closer study and investigation when eradication operations are in progress and a number of pine stands are thoroughly freed from this broad-leaved host, not only from inside the compartments, but also from outside, to a minimum distance of about 200 yards from any young growth of pine. When the source of infection becomes limited to a few areas it will then be possible to make a more accurate investigation.

The range of dissemination of the æcidiospores as well as their longevity in the case of *Cronartium ribicola* are subjects about which there is considerable difference of opinion. Spaulding in a recently published bulletin (25) has summed up his observations on this subject in the following lines. This range has been determined " up to 1¼ miles with scientific accuracy, with less accuracy up to to 7 miles and still more recently by the elimination of other factors upwards to hundreds of miles ". Experimental data on the longevity of the æcidiospores vary from 3 weeks to 6 months. But this includes spores which were stored under artificial conditions. Under favourable conditions the spores may also retain their viability better in nature than under adverse experimental conditions. Strong light, excessive humidity or excessively dry conditions and high temperature are factors which have a deleterious effect and stand in the way of their retaining their viability for any considerable length of time. In other cases the æcidiospores which are stored in a refrigerator or in a cool place away from strong light may remain in a viable condition for a long time. If the pustules are retained intact the viability of the spores may also be prolonged for a considerable time. Three to seven weeks appears to be the general record of the longevity of the spores under various field conditions.

The "effective range" of distribution of the uredospores of the blister rust of white pine is limited to hundreds of yards rather than miles, while that of sporidia has been estimated to be from 200 yards to a maximum of 600 yards. The longevity of the uredospores has been determined by York (31, 32) who obtained uredospores overwintered on dead *Ribes* leaves and proved thereby that uredospores may survive the winter. The longevity of teleutospores so far as is known for that species, as noted by McCubbin (19) is 55 days but the maximum germination took place within 4 weeks from the date of collection of the leaves. The delicate sporidia which may be distributed up to 600 yards and occasionally may be carried to a greater distance in a viable condition can live in suitably moist air up to 26 hours and then readily germinate when moisture is supplied.

From the results of the experiments and actual field observations done by the writer and from the information available on this subject from the investigations on the white pine blister rust by European workers, a distance of 3 miles for æcidiospores, 600 yards for uredospores of 200 yards for sporidia may be taken as the preliminary working distance for control purposes. Detailed work is in progress and in course of time when exact data are at hand a further announcement on the "effective range" will be made.

(*e*) *Weather conditions in relation to Swertia infection.*—Our knowledge about the factors controlling successful infection of *Swertia* by the æcidiospores in nature is admitted to be rather incomplete. But the following observations which explain to some extent the relation of *Swertia* infection and weather conditions are based upon data obtained during three successive years of field work. It is a well known fact that the infection of blister rust and probably nearly all infection of rusts depends upon moisture conditions during the summer and autumn months. Rain, dew, mist or heavy fog seem to be the natural agencies by which the germination of æcidia and uredospores is effected.

The period of æcidiospore production was found to be lengthened or shortened, even sometimes very considerably, in different years.

In 1927 the æcidia were found to break open by the 1st of May. The heaviest spore dispersal was between the end of May and of June. In 1928 the heaviest spore dispersal was from the middle of June to early July. In 1929 the æcidia began to open by the second week of April and the heaviest spore dispersal was between the 15th May to the 15th June and few æcidiospores were seen by the end of that month, and these dates correspond roughly with the start of monsoon in these years.

In 1927 field study of *Swertia* infection at Ranikhet, Almora and Garkhet ranges revealed a very high degree of development of the *Cronartium* fungus. Little is known of the distribution of infection on *Swertia* in 1928, except from what was seen from specimens occasionally received but it was noted, however, that infection in all the above mentioned ranges and practically all over the infected pine forests of Kumaon closely inspected, was still less.

Rainfall records, however, are found to indicate the moisture conditions for any given locality, the total precipitation for a month indicates roughly the favourableness of the weather during that month for the development of the rust. The rainfall records, which are in fact the only meteorological data available in these stations, are graphically represented from day to day in the Plates IX and X which will partially explain the conditions of weather and their relation to varying degrees of infection of *Swertia*. If these figures are correlated with the infection of *Swertia*, it may be observed also that it is not the total amount of precipitation during the summer and monsoon months that affects successful inoculation of *Swertia* and the duration of the uredo and teleutostages on this host, but, when critically examined, it appears that it is the distribution of the total amount more or less uniformly throughout the infection season which controls the successful infection of *Swertia* either by the æcidiospores or by uredospores and in general the longevity and duration of the succeeding stages.

Heavy precipitation in the period of æcidiospore production has been observed to reduce greatly the dispersal of spores by washing them out of the æcidia. If the rain continues with a heavy downpour for a long time most of the æcidiospores are washed down to the ground and it is unlikely that these spores ever become disseminated in a viable condition by the wind. The same observation holds true for the uredospores and the sporidia also. On the contrary periods of dryness lasting for several days after a heavy fall of rain within a short period may destroy the viability and prevent the germination of the æcidiospores which are thus rendered innocuous to *Swertia*.

The production of successive uredosori in September and October is a point already noted. The uredostage had a shorter duration and limited distribution in 1929 than in the previous years. In 1927 the writer successfully inoculated *S. alata* and *S. angustifolia* at Almora and Barechina in the months of October and November under natural conditions with the uredospores collected from Ranikhet and profuse infection took place. While in 1929, several attempts at inoculating the species of *Swertia* under natural conditions during October and November resulted in failure. Successful results were only obtained when experiments were conducted in moist chambers. After the uredospores begin to form there should be occasional moist periods to permit further infection of the leaves, if there are to be a series of uredostages succeeding one another. In fact, fresh uredospores were frequently collected till the middle of November 1927 and this was evidently due to occasional precipitation followed by cloudy weather both of which combined to keep the atmosphere in a humid condition.

The same observations also hold true for the production of teleutosori, the germination of teleutospores and the production of sporidia. Fresh and newly formed teleutocolumns on some of the infected *Swertias* were collected by the 2nd week of October 1927. Similar fresh teleutosori were also collected by the first week of September 1928, and by the third week of October 1929 and successful germination experiments were done every year till the middle of November. But from those collected by the end of November and early December only a few spores germinated and produced sporidia. The teleutospores attain maturity within a few weeks of their formation. If the moisture condition of the air is unfavourable the germinating capacity of the teleutospores is soon lost and this results in a rapid termination of the life-cycle of the fungus. The dry atmospheric condition, therefore, explains limited production of sporidia as well. After the teleutocolumns are produced there should be a favourable period for the production of sporidia and the immediate infection of pine needles.

The other factor, *viz.*, temperature, is secondary, but none the less explains the absence of pine infection in the warm foot-hills of the Sub-Himalayas. High temperatures are definitely known to prevent germination of these spores, but they do not occur in those regions where this fungus is now spreading naturally.

In order to test propagation under warmer conditions, inoculated *Swertia* plants of various species were transported in pots from Almora to Dehra Dun (2,100 feet alt.) after the appearance of profuse uredosori on them. Though some of the pots were placed in moist chambers, none of the infected leaves developed teleutosori. The uredostage was short-lived and the fungus died out subsequently without the infection spreading any further.

Field inspection in the regions facing the *tarai* and plains throws some light on this point. In Manora range, which faces the plains, and also on the spurs of Mussoorie hill overlooking the plains, one frequently notices all the susceptible species of *Swertia,* and also the young pines flourishing side by side free from this disease. Not far from these forests, from China range, Naini Tal division, and from the northern face of Mussoorie hills infected pines and *Swertias* have been collected. *S. angustifolia* var. *pulchella* and *S. cordata* free from infection have been collected from the lower spurs of the Naini Tal hills facing Kathgodam at an elevation of 2,600 ft. and also on the lower spurs of the Mussoorie hills at Jharripani at 4,000 ft. *S. angustifolia* var. *pulchella* has been collected from New Forest, Dehra Dun. The writer has never come across any infected pine in the warmer valleys of Kumaon, though in places close by but at a higher elevation infection of pine was noticed. Similarly, on the warmer spurs of the foot-hills of the Himalaya facing the plains no infection on either host was noticed though side by side both are flourishing. The striking factor, therefore, controlling the spread of this infection, which suggests itself, is high temperature coupled with the dry atmospheric condition in summer. The spores which are carried to these warm regions either loose their viability or are prevented from germinating. Incidently, it may be remarked here that the leaf-form of *Peridermium* on *Pinus longifolia* (*Peridermium complanatum* Barcl.), which has been described as belonging to another generic group of these rusts, is morphologically a different species and also physiologically behaves differently. This species of rust is common everywhere and flourishes alike in the warm and temperate regions of the Himalayas in spite of varying climatic conditions.

Presumably, then, the amount of rainfall distributed over a longer period followed by cloudy weather, fog and mist, are the factors which primarily control the infection of *Swertia,* either by æcidiospores or by uredospores, the longevity of the teleutospores, the production of sporidia directly and finally the infection of pines. This last point is not merely a logical conclusion, nor one guessed at, but is based also on knowledge of the behaviour of *Cronartium ribicola* in European countries under similar circumstances (12, 14, 16, 17, 21, 23, 24, 26, 32). This point can only be confirmed when data on the rate of mortality are obtained from future field observations and such data may, by comparison with that of previous years and with due allowance for errors, may support the above statement.

(*f*) *Over-wintering of Cronartium himalayense.*—The writer in his attempts to study the phenomenon of over-wintering of *Cronartium himalayense* on the same lines as *Cronartium ribicola* (11, 12, 24, 31, 32) was only partially successful. The main difficulty encountered in the way of successfully solving the problem was the erratic nature of germination of the æcidiospores of this fungus. The writer failed during two years to germinate even fresh spores and in the third year the percentage of germination of such was very low. Side by side with the germination experiments various attempts were made to procure spores from the bark of dead trees, cankered wood, fallen *débris* of pine branches, stumps, cones, etc., where they may be sheltered and such material was frequently subjected to careful microscopic examination for any spores that might be in an apparently viable condition. A certain amount of spores were detected occasionally which had come from dead trees which were killed by the rust during the previous season, but all attempts to germinate them met with failure. During the field study in autumn, *viz.*, from October till the middle of December, the writer also noticed a large number of internal peridia on saplings which had died during the preceding summer. These peridia which were of deep-seated origin inside the bark contained spores apparently in a viable condition. But such fresh looking spores did not germinate in spite of persistent attempts to make them do so. In other cases when small saplings which were actually killed in the spring or summer after the production of a single crop of æcidial sori, were examined during the following autumn a large amount of spores covered by exuded pine resin from the crevices of the bark were found in a completely bleached condition. Attempts were also made with spores kept in storage conditions in a refrigerator to inoculate *Swertia* in the following summer but this proved a failure.

The uredospores which are rather easy to germinate also proved to be short-lived under natural and storage conditions. Inoculating material collected by the middle of November, stored in various ways, never germinated in the following February. Attempts were made to propagate and continue the growth of the rust in the uredo and teleutostages on *Swertia* but this was not possible owing to the annual nature of the host the leaves all falling by the end of autumn and the plants disintegrating in winter. It is therefore evident that such spores cannot remain on any part of *Swertia* and produce the teleutostage in spring and infect the pines. The *Swertia* host completely decomposes during winter and the possibility of this stage over-wintering on *Swertia* does not arise.

In any case it is unlikely that the æcidiospores retain their viability in this climate under the prevailing adverse natural conditions so as to infect the broad-leaved host which appears in the forest after one full year. The strong sun and daily variations of temperature and heavy rains during the monsoon and early autumn, are factors which stand in the way of their retaining their viability till the next season. Consequently, the phenomenon of over-wintering of the above spore-forms seems most unlikely with *Cronartium himalayense.*

VIII. GENERAL CONSIDERATIONS.

(*a*) *Pinus longifolia* (*chir*) is one of the most important forest trees in the Himalaya ; in the United Provinces it forms, after *sal*, the most extensive forests in the province (1). It is found both on the outer ranges and in the principal valleys of the Himalaya, descending occasionally to an elevation of 1,500 ft., to the level of the main water courses and ascending to 7,500 ft. on the warmer spurs of the hills. This pine is typically gregarious forming pure forest of considerable extent. According to Troup (28. 29) the upper limit of gregarious *Pinus longifolia* forest may be placed at 6,500 ft. and above that elevation the tree is usually found scattered in warm aspects up to 7,500 ft. or even higher. In its upper reaches it is associated principally with *Cedrus deodara, Pinus excelsa, Quercus incana, Rhododendron arboreum* and *Myrica nagi*, while in its lower habitat it is mixed with *Shorea robusta, Anogeissus latifolia, Terminalia tomentosa, Buchanania latifolia, Ougenia dalbergiodes*, etc. The area covered by this pine has been roughly estimated by Troup (28) to extend over about 3,300 square miles, extending from Sikkim, through Bhutan, Nepal and Mandi to the Frontier States and Afghanistan. The total area of *P. longifolia* forest including the territories mentioned must be considerably greater.

In the Kumaon and Garhwal Himalayas, where this disease of *chir* has taken a heavy toll and is extending to new areas every year, this pine forest either pure or mixed extends over a large extent of hilly country between elevations of 3,500 and 7,000 ft. On northern aspects pure *P. longifolia* forests occur mainly at elevations of 3,500 ft. to 5,500 ft. and on lower elevations this pine is mixed with the various broad-leaved species already referred to, while on higher elevations above 5,500 ft., the pine rarely forms pure forests and is mixed with *Quercus incana, Myrica nagi, Pieris ovalifolia* with or without *Rhododendron arboreum.*

Troup in his interesting memoir on *Pinus longifolia* (28) has predicted in the following lines a great future for *chir.* " Forming, as it does, gregarious forests at comparatively low elevations, its timber can be worked out at a lower cost than is the case with species growing in more sporadic form and in less accessible tracts. True, the timber, though of very fair quality and in considerable demand, does not rank among the first class timbers of India, but when the value of antiseptic treatment comes to be more fully realized in India more extensive uses should be found for it. Apart from this, the tree has already established its reputation as a producer of resin, and in this respect alone is of great potential value, since there is room for an extensive development of the resin industry in India."

Within the last few years this statement of Troup has already materialised to a great extent and the importance of *chir* timber for building purposes and for ordinary furniture and in general carpentry has risen much in the estimate of the people. It is now extensively used for these purposes in the principal cities of North and North Western India. It was formerly regarded as a third class timber for railway sleepers, bridge building timber, shafts and other strong constructional works, but under modern treatment with preservatives it has been lately proved to be a first class timber for all purposes. A large number of sleepers are being annually treated and under modern treatment with preservatives it is also possible to use sapwood of *chir in toto.* From the economic point of view *chir* sleepers are about the best proposition for the railways in India to-day.

This pine is at present the principal resin producing species in India. In the Punjab and the United Provinces it is systematically tapped. The amount of pine resin extracted in 1928 from the United Provinces forests was 105,600½ maunds and was sold for Rs. 3,36,370 (1). The resin industry of the Punjab has also developed rapidly. The importance of *chir* pine for this purpose may increase in future as communications extend into the interior and larger areas are tapped.

This pine is also of considerable importance as a park, garden, avenue, and ornamental tree. It is a large evergreen tree, sometimes nearly deciduous in dry localities, and having an elongated crown up to middle age. It grows quite rapidly and acclimatises itself easily outside its natural habitat. It spreads a pleasant aromatic odour in the locality where it grows. For these reasons it is planted in parks. It is sometimes reared as a decorative tree up to the pole stage in the compounds and gardens of houses in North and North Western India. Though *chir* produces an inferior quality of fuel wood, in the Kumaon hills in the absence of better kinds this wood is extensively used for this purpose.

(*b*) *Damage due to the infestation of blister rust.*—There is a tendency amongst forest officers in India to believe that the disease will not become serious in stands of natural regeneration where the pine is growing luxuriantly under favourable conditions in its natural habitat and that attacks will only be confined to plantations, where the host is weakened in some way so that it becomes susceptible to the parasite. It cannot be denied that the principles of phytopathology and so also that of animal pathology assume the fact that the individual receives infection only when it is weakened in some other way, which suggests that there must be some factors for predisposition. This assumption to a certain extent holds true in most of the plantations which the writer had the opportunity of examining during his tours. It is known for certain that this rust is a member of a group of well-known parasites and that their mode of entry is through the stomata of the leaves and especially of primary needles; the causes of the production of these primary needles, which arise from adventitious buds on the stems of advanced saplings and in larger numbers on unhealthy saplings in plantations, may therefore be regarded as predisposing factors to the disease. The saplings in periodically burned young regeneration, for certain physiological reasons not thoroughly known, also produce copious adventitious buds all over the stem and when the leading shoot dies for some reason such buds grow out into a number of shoots and the plant attempts to coppice. On the other hand, as far as the leaf sheath infection is concerned, this factor is equally responsible for such infection both in plantations and in regeneration, artificial or natural. In fact, the result of field study in the Kumaon and Garhwal forests, as already referred to, supports the belief that healthy and vigorous regeneration is as much open to such danger as plantation crops. This statement is further supported by results so far available of cross-inoculation experiments of pine which were done during October 1927, when 120 saplings of various ages were inoculated, the plants being selected from healthy members of the regeneration and plantation areas. It is too early to report on the results of these experiments but they will be a subject of future discourse; it appears however that some of the inoculations done on the leaf-sheath and on the primordial needles of the adventitious shoot have taken effect and are now showing symptoms of the disease.

It is not possible to state the exact figures of mortality of *P. longifolia* in the Kumaon and Garhwal forests. The area concerned is extensive and the writer has not succeeded in accumulating the necessary data. The following record however will give some approximate idea of the heavy casualties in the Almora and Bhowali plantations. The data on the mortality of pine in the Almora plantation has been taken from a published record (30) on the methods of slash disposal in the *chir* forests and the other from the official record of Naini Tal Division for which the writer is indebted to Mr. E. W. Raynor, I.F.S., Divisional Forest Officer, Naini Tal. The record of mortality in regeneration compartments is, unfortunately, not kept.

Mortality of *P. longifolia* in the vicinity of Almora,

West Almora Division.

1922-23	5,183
1923-24	2,615
1924-25	5,147
1925-26	7,399
1926-27	3,980
TOTAL	24,274

Naini Tal Division 1927-28.

	Girth.	
	0"-6"	6"-1"
Gager Compartment 20	400	200
Ninglat Compartment 1	120	..
	520	200

It will require several years' work to get a complete record of the huge number of casualties and then only will it be possible to work out other details in terms of expense and the exact amount of loss from this disease, but it will now serve our purpose if we only succeed in impressing those concerned of the extent of the loss, as compared to any other loss of forest trees in this country due to fungus infestation, and, what is more, the danger to which this pine is exposed and by which it is being overcome.

(*c*) *The origin and distribution of Cronartium himalayense.*—The history of *Cronartium himalayense* is very obscure. Though occasionally specimens of the æcidial stage of this fungus were collected as far back in 1889 when Barclay (5) noted the *corticola* stage on *Pinus longifolia* and Nisbet in 1895 (20) no reference has been made to the *Cronartium* stage on *Swertia.* It is interesting that while examining *Swertia* specimens in the Dehra Dun herbarium the writer came across two sheets showing *Cronartium* fungus. One is a specimen of *S. cordata* collected from Pasada, Bashahr, altitude 6,500 ft. and the date of collection is October 1891. The other specimen is *S. alata* from Dharmigadh, Jaunsar, altitude 5,500 ft. collected by J. S. Gamble in September 1898. A specimen of *S. alata* showing *Cronartium* infection was also seen at the herbarium of the Royal Botanical Gardens, Sibpur, Calcutta. Bashahr is a division lying to the north-west of the Simla hills and Jaunsar lies to the east-south-east of Simla and north-northwest of Dehra Dun. The presence of this stage of fungus on both sides of Simla is an interesting fact and one can easily assume its presence in Simla as well, though it has not been actually noticed there and Barclay collected his specimens of *corticola* in the neighbourhood of Simla about the same time.

It is interesting to note that Dr. E. J. Butler, the then Imperial Mycologist at Pusa, who visited this part of Kumaon several times and in different seasons for the study of wheat rust and for collection purposes with an efficient staff of collectors did not come across any specimen of *Cronartium* fungus on *Swertia*, in spite of the fact that several other specimens of rust had been collected from Kalimat, Sitoli and the plantations close to Almora. It is quite possible that this fungus was not there at the time when he inspected these forests and that it might have spread to this area later on.

From the records of the Almora plantations, it was noted that in 1891 a large number of young *chir* trees were dying of some insect attack. The attack was at its worst in 1909-1912 when a large number of sickly and attacked saplings were burnt. No further reference to this is made till 1914 when the Divisional Forest Officer noted that an attack of the insect had caused a considerable number of casualties among the young *chir* pines. Thereafter casualties were sporadic. In 1915 *Peridermium* was for the first time definitely recorded as apparently doing much damage. It was noted by Champion (7), Beeson (6), as well as by the writer (3) that *Peridermium* is the predisposing cause and the insect comes in later when the trees are almost dying. It appears, therefore, that some earlier attacks of *Peridermium* were not detected and the insects which were secondary might have been mistaken for the primary cause of mortality of *chir*.

It is difficult to say what is the original home of this fungus. Both *Pinus longifolia* and *Swertia* are natives of the inner Himalaya as well as of the outer Himalaya facing the Indo-Gangetic Plain. *Cronartium himalayense* may have its original home in the inner valleys of the Himalayas and it may have migrated to the outer ranges later on. In the absence of any other fact to prove the contrary the fungus may be taken to be of Himalayan origin and from this point of view the name *Cronartium himalayense* is appropriate for it.

In connection with the description of the æcidial stage on *chir* pine (3) the writer has given a list of distribution of most of the infected compartments of West Almora and Naini Tal divisions. The fungus has since been noticed in the Pindar and Dhanpur ranges in Garhwal division. It has also been noted in the western border of West Almora in the Kapoli and Chakargaon plantations (Plate V) of the Dwarahat range. Though not in a general epidemic form it occurs also in the East Almora division. It has also been recorded in Mussoorie, Chakrata, Jaunsar and Simla, and the Bashahr and Kulu divisions. It probably also occurs in Mundi, Kashmir, Hazara and Chamba. Outside India proper, there are *chir* forests in Sikkim, Bhutan, Nepal and in the Frontier States of Afghanistan, which still remain botanically unexplored. As these are gradually explored we may be able to give more complete information regarding its distribution in these states bordering India proper.

(*d*) *Important dates in the life history of Cronartium himalayense and its life cycle.*—The pycnidial stage is noticed on pine in October and November in the form of small lucid honey-coloured drops at the base of the needles of the infected tree. It is sometimes seen close to the canker at its earliest stage on the stem of saplings where the pycnidial drops are mixed with exuded resin. The pycniospores are believed to be abortive spores which have become functionless.

The æcidial stage may appear in the following spring or a year later on the same parts of the plant where pycniospores were detected during the previous autumn. The earliest crop of æcidial sori was collected by the writer by the 1st week of April and they continued to be produced till the first week of July. In the case of young seedlings the plant dies off before the æcidiospores are formed on them. Inoculation experiments with sporidia on various ages of pines are in progress. But those experiments which were done on very young pines that is on seedlings between one and two years of age proved successful. Such plants died within one year after inoculation and histological examinations showed the presence of numerous hypæ and haustoria in the cambium and cortical cells of such plants. Trees of various ages from 3 to 16 years have been frequently found infected by this fungus which fructifies copiously and produces numerous æcidial sori on the stem and branches. Beyond this age infection by *Cronartium himalayense* is uncommon. The oldest tree recorded to have been killed by this fungus was a pole about 30 years old.

The uredostage was noticed on the 6th July 1928 on *S. angustifolia* and by the 18th July on *S. alata* and on *S. cordata* on the 4th July. This stage was noted about the same time during the following year. In 1927 when the search for the alternate host of *Peridermium* was commenced on the 16th October, the uredostage was found mixed with the teleutostage in Kaligadh on *S. alata*.

The teleutostage was noted by the middle of August on *S. angustifolia* and by the end of August on *S. alata*. They appeared through the uredosori first and the pure teleutosori appeared all over the undersurface of the leaf.

The maximum growth of *Swertia* is generally over by the end of September, most plants flower in October and the seeds mature by the end of October when the capsules open to discharge the seeds. The dispersal of seeds continues till the end of November when practically all the capsules become empty of their contents. *Swertia* completely dies off by the end of December. One may trace small pieces of stem here and there in the forest in January but after this time the winter snows and rains disintegrate whatever woody structure remains of them so that in April the plant is not seen at all. They reappear by the middle of June and in two weeks attain the size of 2 to 3 inches. It has also been mentioned before that *Cronartium himalayense* does not over-winter either in the uredostage or in the teleutostage.

IX. CONTROL METHODS.

Under this heading various methods of control of this blister rust are considered, not only that of the eradication of one or the other host, a well known prescription for the such diseases of forest and agricultural crops, but also other possible treatments are taken into account such as a change in the practiced silvicultural system of regeneration, encouragement of mixtures, departmental burning, etc., if such measures appear to help in natural control and serve our purpose. The various measures will be discussed in the following pages and each will be taken up in the inverse order of importance.

(*a*) *Substitution of chir with other Indian or foreign pines.*—It appears from the above investigation that *Pinus longifolia* is extremely susceptible to blister rust. The main problem under this heading resolves itself into a single question, *viz.*, can we grow any other pine, Indian or foreign, which will be silviculturally well suited to those extensive areas where *P. longifolia* is now flourishing and which will be an equally sound economical proposition ? The important silvicultural characters of this pine may be summed up in the following lines.

It is a strong light demander and warmth loving plant. It grows successfully in the plains and in places with a hotter and drier climate that it experiences in its natural habitat. *Pinus longifolia* seedlings are light demanding also. It reproduces itself well as a rule on well drained porous soil, such as those containing a fair proportion of sand or fine mica. *Chir*-pine grows on a variety of geological formations from clay soil, beds of conglomerate to decomposed mica-schists, gneiss and even on hard shales with quartzite. It has been found that this pine grows in the crevices of quartzite and even on bare rock with a very small amount of soil in the buttresses and crevices.

The young regeneration of *Pinus longifolia* requires to be protected from damage by fire. Although this pine is regarded as being a fairly fire-hardy species in a sense that a mild conflagration does no serious damage, it is, when young, susceptible to damage by fire and the pine regeneration requires to be protected for some years. The accumulated *débris* consisting of needles, broken branches, cones and other parts of the tree together with the exuded resin at the base of the trunk and felled stumps form a great mass of inflammable material, which, unless burnt departmentally under control, is liable to accidental or intentional burning. This pine has a greater power of resistance to fire than any other important Himalayan conifer, owing to the exceptionally thick bark produced on young saplings and on advanced trees and to the power of recovery from injury possessed by plants of various ages. Saplings of from 2 ft. upwards are subjected to a moderate fire during the slash disposal operations which no other species would stand. Keeping these few facts in view it now remains to be seen if there is any other Indian pine which has the same silvicultural characters as *P. longifolia*, keeping in mind its power to regenerate itself under the unfavourable circumstances with which *chir* copes so successfully,

Pinus khasya, Royle, is another Indian pine which grows gregariously as well as mixed with other minor species such as *Rhus semialata*, *Quercus serrata*, *Myrica nagi*, *Pieris ovalifolia* and *Rhododendron arboreum* under somewhat similar climatic conditions on the Eastern ranges as *P. longifolia* does on the central and western ranges of Himalaya. It grows in Assam, North Burma and the Shan States from 2,500 ft. up to 8,000 ft. elevation. It is also a light demander, though perhaps not to the same extent as *chir*-pine and to a certain extent can also stand shade. There is a species of *Peridermium* which infests this pine which has not yet been properly identified. It produces marked hypertrophy of wood and bark which appears as "burrs." The fungus is known as *Peridermium* near *cerebrum* and there is only one specimen which has come to our hands so far. This pine, however, appears to be a resistant species. Economically this pine, although producing a superior quality of resin, from the point of view of timber may not be ranked with *P. longifolia*. It is a slow growing species and cannot therefore equal *chir*-pine in height growth. Several unsuccessful attempts have been made to introduce this pine on the pleateau of Central Provinces and in the United Provinces in Chakargaon in West Almora and in other places away from its natural habitat.

P. excelsa, Wall. and *P. gerardiana*, Wall. are both unsuitable as the former is a temperate and the latter is a dry zone species. From their habitat and for silvicultural reasons these pines do not merit any further consideration. These species will never regenerate naturally where *P. longifolia* thrives.

Of the foreign pines, just a few species, such as *P. ponderosa* and *P. arizonica*, have been given occasional trials here and there, but nowhere has this been done with a view to replace any Indian species or to acclimatise them to the Indian climate, and it is doubtful if any of these foreign species will be suited to us silviculturally.

Consequently, the proposition of substituting the native *P. longifolia* with these foreign species will not be welcomed here from silvicultural and economic points of view. Such a proposition can only be entertained when one has to keep his choice between two exotic-species.

In a recently published work Spaulding (23) has advocated in a similar contingency the replacement of *P. strobus* by *P. excelsa*, *P. peuce* and *P. cembra* where none of these species of pine is native of the United States. In India *P. khasya* is a native of the Eastern Himalaya and, so far as known, appears to be a species immune to blister rust, but such small scale trials as have been made with it have not given any promising results and the proposal of its replacing *P. longifolia* in the natural habitat of the latter in the North Western Himalaya is a point which even if possible would probably be regarded by the local forest authorities with disfavour.

(*b*) *Encouragement of selection system in chir regeneration.*—The prevailing method of *P. longifolia* regeneration in most of the Kumaon and Garhwal forests up till 1920 was some form of selection system, by single trees or groups, which resulted in uneven-aged crops. Owing to the light-demanding nature of pine and its tendency to regenerate where possible in even-aged masses such a system of selection felling was abandoned in favour of the uniform method. Besides, owing to the work being scattered the subsequent tending of the young crop in such areas worked under the selection system becomes difficult. The suppression of young growth takes place and the clearing of slash and *débris* from the uneven-aged stock also becomes difficult. Controlled fire operations and other measures for fire-protection in areas under regeneration are impossible, consequently, damage by fire is intensified in an uneven-aged crop of the selection type. For those and for other economic reasons, in subsequent working plans the selection system of working *P. longifolia* has been abandoned in favour of the uniform method which has been worked at least for 10 years in a satisfactory manner. Under this system, even-aged, healthy and uniform masses of regeneration are coming out all over the area where felling has been done and damage by fire avoided.

From several years of field investigation it has been observed that the rate of pine infection and its relation to different types of pine stands, *viz.*, plantation and natural regeneration do not follow any definite law. It has also been noted that vigorous saplings are as much open to the infection of rust as the weak ones.

The plantations of Almora range, Kalimat, Baldhoti, etc., which cover an area of over 1,000 acres are raised by patch sowings. The forests consist of growth of all ages from saplings to poles. Khabdoli South, West Almora divisions, Sukha and Nichna, Naini Tal division, Pindar-Par and Deosari blocks in Garhwal division are forests where even-aged, healthy crops are coming up as the result of feelings in Periodic block I. Comparing the rate of infection in these two types of *P. longifolia* forests in Kumaon, though both of course are badly infected, it appears that the former, a plantation on shallow soil, is in a better condition than the regeneration of P. B. I where significant gaps are being formed through widespread infection.

There are two points which have got important bearings on this problem under consideration, namely, the susceptible age of the tree to infection, and secondly, the relation of weather conditions and pine infection. It has been noticed that beyond a certain age the *chir* pine proves to a certain extent to be immune to blister rust. It has been already mentioned that the adventitious buds which are one of the important channels of stem infection are not developed after a certain age, at least, they are rarely found on saplings which have grown over 15 to 20 ft. in height. The other entrance of this fungus is through the stomata near the top of the needle sheath where the sporidia get lodged. In the case of advanced saplings and poles the infection of the leading shoot above 6 ft. from the ground is of rare occurrence. In such trees the infection is generally noticed on the branches while the infection on secondary branches at any height up to 6 ft. has been frequently noticed on trees up to 20 years of age. As the tree advances in age, the lower branches are suppressed and die off naturally. Consequently such infection on the branches towards the base of the tree fails to spread on the stem. The lower branches of trees which are passing out of the pole stage extend outwards away from the stem. The infection of such branches which takes place through the medium of mature needles is often limited to a region at a distance of 2 to 3 ft. from the axil of the stem. In this case also such infection does not generally spread on the main stem. The branches being girdled, the supply of sap to the leaves is cut off. These branches soon drop off before the parasite has a chance to invade the leading stem. In this respect *chir* is better able to ward off fungus attack than the susceptible species of white pine of Europe, where, in connection with the age of the trees infected by *Cronartium ribicola*, Spaulding notes (24, 25) that in *Pinus strobus* trees of all ages from 4 to 118 years were killed by the blister rust. But so far as the *chir* pine is concerned this important deviation has been noticed. It is certain that advanced and middle-aged trees are so far safe. The oldest tree that was noticed to be attacked by this fungus was a pole of about 28 to 30 years. The infection took place on a branch at a height of 17 ft. and the tree was girdled from that region.

The weather conditions in these forests and their relation to pine infection deserve a few remarks. Air saturated with moisture and a low temperature are essential factors for natural infection. It has been observed that the prevalence of favourable conditions during the rains and autumn, such as cool nights and mornings with sufficient humidity are also helpful for *Swertia* infection. Similar observations have been made by the European investigators on white pine blister rust (9, 21, 26, 32). As the weather cannot be controlled the discussion may be confined to the other point, namely, the relation of the age of the pine to natural infection.

An even-aged crop appearing in extensive masses is more difficult to protect from an epidemic disease when the species concerned are at one age particularly susceptible to infection than on uneven-aged growth coming out in different groups. The latter class of regeneration has certainly advantage over the former in evading the attack of the disease so far as natural infection is concerned. From this point of view even group selection may be considered as a protective measure against widespread infection of the young regeneration. But the other side of the problem may have equally or even more weighty support from the silvicultural and forest management point of view. Extraction and sales of timber, slash disposal, controlled burnings, etc., would offer considerable difficulties in an area regenerated under the above system.

(c) *Departmental burning.*—The effect of controlled burning operations either to control the disease or to help as a preventive measure was studied in the course of field investigation. The primary object of this operation, as has already been stated, is to remove the amount of *débris* of fallen needles, branches, cones, etc., which stand in the way of seed germination and secondly, the removal of inflammable material which if allowed to accumulate, becomes a source of serious danger from fire. It has also been observed that such burning preparatory to regeneration improves the condition of the soil considerably from a physical and chemical point of view, brings out the regeneration in profusion and gives it an extraordinary stimulus in establishing itself. *Chir* seedlings are exceedingly sensitive to fire unless they are protected from fire, it is impossible to keep the regeneration alive. Young crops are therefore not burnt until they attain a certain age and even then, the intensity of the fire is controlled.

Up to this stage the problem is quite straightforward but difficulty arises later on when subsequent or periodic burnings at an interval of two or three years are prescribed. The dangerous nature of the accumulated slash and the intensity of the damage due to fire unless the slash is disposed of periodically has been noted elsewhere. For the later tending of the young regeneration this departmental burning seems essential and is considered to be the cheapest way (30) of disposing of this slash and *débris*. But whether such periodic burning is a beneficial operation from the physiological and pathological point of view requires further observation.

The ecological side may be left to those who are competent to deal with it. The vigour of the plant is lowered considerably if it is burnt when a young sapling. This is expressed in the shape of various abnormal phenomena that appear during the subsequent history of the plant, *viz.*, the gradual dying off of the leading shoot (Plates VI and VII), attempts to coppice heavily, the formation of tumours at the collar, the formation of blister and cankers on all parts of the stem affected and the subsequent excretion of resin. The growth may be stopped or reduced for some time. In the case of young regeneration as well as in advanced growth the lower branches are often killed and numerous adventitious shoots appear around the stem from the collar up to a height of 3 to 4 ft., sometimes even up to 6 ft., depending upon the age of the sapling and on the intensity of the fire. These phenomena can be partly explained as the result of an attempt on the part of the plant to recover as if from a great shock. It has been specially noted that a large number of adventitious shoots which are generally the medium of entry for this fungus are apparent on most of the saplings in the infected stands of the Nichna and Sukha blocks, Naini Tal, of the Khabdoli South and Garnath blocks, West Almora and in the regeneration areas of Pinder-Par and Deosari in the Garhwal Division. The adventitious shoots do not always drop off from their base after they are dead, but remain for two or three years as a dried tuft of bristles attached to the bark. From these dried needles the presence of such adventitious buds or shoots could be recognised even after the saplings are killed by the attack of blister rust. The plantations of the West Almora division have not been subjected to this departmental fire operation, except on one occasion in 1921 when incendiary fire damaged the plantations. In the Kalimath and Baldhoti blocks the writer noticed a certain amount of these dried needles on the saplings.

On the stem and branches of *chir* pine there always appear ring-shaped depressions encircling them, whence the secondary or tertiary branching takes place. These rings are noticed for several years even after the branches drop off naturally and they disappear later on with the advancing age of the tree. Branching takes place in whorls round this ring. Some of the initial buds develop into branches but others remain dormant and gradually die off unless stimulated by abnormal factors, when they develop into adventitious shoots with a large amount of primordial needles. A large number of such buds is always seen on the stem and branches of *chir* pine in a dormant condition. Fire is one of the principal factors, though not the only one, which stimulates growth in them. When the leading shoot is killed or injured by fire, or snow, or by some other agency these dormant buds also produce foliage. The injury caused to a stem by a galvanised iron wire tightened round it produces, in the course of two and a half or three years, a large number of adventitious shoots (Plate VIII). These adventitious shoots appear when the plants are young and they are seldom noticed on saplings which have grown up to about 15 to 18 years age and over.

It has also been noticed that the *chir*, when growing in poor shallow soil or in any unfavourable locality, produces a large amount of such adventitious buds. Excessive dryness of soil during a year of abnormal drought may produce a large number of these adventitious buds.

It appears, therefore, that there are in *chir* up to a certain age a large number of buds which remain on the ærial parts of the plant, the branches and stem, in a dormant state under natural conditions and when there is a certain change in the normal metabolism or obstruction in the movement of sap these buds develop copiously as adventitious shoots, and so far as has been observed, fire is one of the causes which stimulates them to form such growth. So far as the writer has observed there are excellent patches of almost complete regeneration in Khajuri block in West Almora Division and in Patlot Block in Naini Tal Division which in 1921 were not burnt departmentally or otherwise, and in which no infection was present when these were visited last in June 1929.

There is one other point of importance which deserves consideration and that is the effect of fire on the propagation of *Swertia.* It has already been noted in connection with the germination experiments that the minute seeds of *Swertia* drop from the capsules from the middle of October till the middle of December and after this hardly any seed is found in the capsules. These seeds are very minute and, even when dropped on ground covered by grass, moss or weeds, filter through, helped by occasional rain and other agencies, and ultimately reach the soil where they become quickly covered by a thin layer of humus formed by the decomposition of fallen pine and other leaves and of grasses and herbs and during the autumn and winter rains by a thin layer of fine micaceous soil. This layer, though thin, acts as an effective non-conductor of heat and fire passing over has practically not harmful effect on the seeds.

This statement is supported by the fact that *Swertia* frequently occurs on fire lines which are burnt every year and from the fact that the writer observed that two fire operations in the Garkhet and Pindar compartments between 1927 and 1930 did not have any effect on the *Swertia*. Again, when *Swertias* appear in colonies or as isolated patches outside the compartment, as is often noticed in some regeneration areas, fire seldom reaches the source of infection.

In conclusion fire by killing the leading shoot and lower branches of the saplings, or by injuring them, stimulates the saplings to coppice and the adventitious buds to produce numerous shoots with primary needles. These needles are the channels of entry of the *Cronartium* fungus in pines. On the other hand burning has no effect either to stop or even to reduce the propagation of the *Swertia* host.

(*d*) *Admixture of chir with other species.*—A good deal of attention was given to the study of the nature of infection in mixed growth where secondary broad-leaved species have been growing naturally or introduced along with the *chir*. Of the various associates of *chir* where this pine grows with deciduous broad-leaved species the following, which have some economic importance as fuel producers are the most common *Quercus incana, Rhododendron arboreum, Pieris ovalifolia, Myrica nagi.* Of these *Quercus incana* deserves consideration.

To a certain extent this oak is worked as a species secondary to *chir*, deodar and blue pine. Economically it is valued for the excellent charcoal and fuel it yields. It is also used to some extent as an agricultural timber for the construction of ploughs and other implements.

None of these blocks which were inspected by the writer gave any clue to the solution of the problem from this point of view, except the regeneration of Bhowali, Naini Tal, Chaubatia and Siuni, Ranikhet and Sihai-Devi, Almora which gave some insight into the problem. In all these blocks sporadic infection of pine was noted. The use of such broad-leaved species as a wind-break to check the dissemination of spores did not appear to be an effective method of control. The distribution of *Swertia* in such forest where the pine is mixed with other species is generally scattered and infection takes place at close range, consequently, in such cases this method may not be of any value as an effective control measure. But in other cases where the source of infection is in groups or in isolated colonies, which is generally the case with natural regeneration, such intervening broad-leaved species may form a wind-break and may check the progress of infection from one compartment to another.

But there are other factors which have to be considered, such as the amount of sporidia produced on different species of *Swertia*. All species of *Swertia* do not produce an equal number of spores. The teleutospores of *S. alata* produces a greater amount of sporidia than those of *S. angustifolia*, though the amount of infection on the later species is greater than the former. Again *S. angustifolia* has a much wider distribution. It is not only a species which occurs very frequently in pine forest but always grows in greater numbers than *S. alata*. On the other hand the spores and sporidia remain longer in a viable condition on the leaves of *S. alata* than on the leaves of *S. angustifolia*.

This phenomenon of the difference of the amount of sporidia production has also been noted in the case of *Cronartium ribicola*. The use of broad-leaved species as wind-breaks has given good results in the case of *Cronartium ribicola* in America (25) where the supply of sporidia is not excessive, while in Europe, where *Ribes nigrum* furnishes a superabundance of sporidia the effect of such intervening screens in reducing infection is not noticeable.

In any case, the problem of the admixture of other forest species with *chir* deserves closer study. For this purpose several planting areas should be selected in the neighbourhood as well as at a good distance from the infected blocks and different methods of sowing adopted for such mixed sowing experiments, *e.g.*, sowing of pine and oak in regular order, broadcast sowings of two species, several rows of pine followed by a number of rows of oaks and so on. One experimental plot has already been laid out by the Divisional Forest Officer, West Almora, at Katarmal. But many more plots in different localities sown in different ways, as stated above, each with a control plot, are necessary to procure any reliable data from such an experiment. The result of such experiments might lead to some practical suggestion, with regard to the solution of the main problem. It must, however, be realised that most likely species for such admixture are fire tender and so cannot be raised with controlled burning.

(*e*) *Removal of the infected chir and destruction of the æcidial stage.*—If after having investigated some of the methods of current silvicultural technique adopted in regenerating *chir* pine a proper solution of the problem could not be arrived at, the eradication measure now remains to be discussed as the ultimate resource to fight out the disease. *Cro-*

nartium himalayense like *Cronartium ribicola* is essentially a heteroecious rust as proved by the inoculation experiments of Champion (7) and confirmed by a large number of experiments conducted by the writer who inoculated 60 *chir* saplings with æcidiospores under different conditions, in 1927, 1928 and 1929, without any success. If one form could be completely destroyed it follows that the other stage becomes automatically eliminated. The removal of the infected pines from the forest and the complete destruction of the æcidiospores by burning is the control proposed by Champion and this has been carried on by the forest department in the United Provinces for the last 10 years. This method does not appear to have been successful. To strictly enforce this measure and to prevent the dissemination of the spores to any great extent during such operation appears to be almost impossible. What prevents this method of control from being strictly carried out is that it is not always possible to burn the infected trees at the proper time, as they are only detected after the æcidial sori have appeared all over the stem, and it is not always possible to burn the infected trees as soon as they are noticed. The æcidial sori in the majority of cases become apparent on the trees during the height of summer, when there is a large amount of dry needles, grass and other inflammable matter, already mentioned which makes this proposition difficult from the point of view of fire-control. The common practice, however, in such cases is to cut down the tree from the collar and then to drag it up or down the slope a distance of several yards either outside the compartment, or to a comparatively open place where it is left for some time to dry up and where later on, it is burnt along with other slash and dry leaves. This naturally foils the purpose of the operation as during the process of felling and removal of the tree bearing pustules a large amount of spores are always disseminated. The writer himself repeated this operation by felling saplings in a similar manner and removing them uphill along the contour to a distance of 30 yards and it was noted that by the method of felling alone about 60 per cent. of the unopened pustules had burst with the result that about 80 per cent. of the spores were discharged, while others, which were already open, became almost emptied of their contents before the operation is completed. The saplings were removed as carefully as possible without being knocked against brambles and other plants as would be expected under the supervision of forest guards. The only obstruction they met during the experiment was the uneven grassy slopes. The rate of spore dissemination would naturally be much less if the saplings were burnt on the spot as is done in some cases when there is no other young growth in the neighbourhood of the dead pine, failing which the removal of such trees down-hill and through less obstruction *en route* would be a better method though even then one could not avoid the dissemination of a large number of spores. There are other factors which operate during the process of removal, such as the distance to which these plants are removed, the obstructions along the route such as brambles, hanging branches of other forest trees, boulders and stones, contour faces and so on. These factors vary from one case to another and it is difficult to estimate the rate of dissemination of spores during the removal of such trees.

The following points should be considered if the removal and burning of the diseased pine trees is to be carried through with a view to destroying the æcidial stage and so reducing the dissemination of the number of spores liable to infect the alternate host.

(i) An endeavour should be made to identify diseased saplings in the field before the æcidial sori appear. If this could be done the spore dissemination which generally takes place during the transport of the felled plant from the forest, will be eliminated. By careful observation one may detect the infected plants, the symptoms of which have already been described in details in a previous paper (3).

(ii) The infected tree, if possible, should be burnt on the spot. This is perhaps a difficult matter, as the shedding of needles generally starts in May or even earlier on the warm spurs and drier slopes and the accumulated needles together with old cones and other *débris* and exuded resin form a mass of inflammable material. Unless these are removed and the tree is isolated it would be difficult to control the fire. If the infected tree is a small sapling the æcidial pustules could be burnt to get rid of the loose spores. After this, the tree should be cut down with a sharp implement and finally burnt after it has dried up, in order to destroy the spores which are caught in the base of the pustules, in the crevices of the bark and in other parts of the tree. In fact, the drying up of the tree is not necessary, nor is it necessary to burn it to ashes, because scorching the bark and parts of the tree will kill the spores if this is properly done.

(iii) The diseased saplings should be removed to the nearest open ground devoid of slash and *débris* with as much care as possible and minimum obstruction *en route.* Painting over the æcidial patches with tar, molasses or any similar sticky substance, before cutting and collecting for burning should reduce risks of disseminating the spores in the course of these operations. This has been done in the East Almora Division but not under controlled conditions so that the value of the precaution cannot be assessed.

(iv) The disseminated spores are not only lodged inside the crevices of the bark of the infected tree and between the needles and their sheaths, but a large amount is lodged in such parts of the neighbouring pines. A certain number also find their way inside the leaf-sheaths of tall grasses, on the leaves and the axile of the leaves and branches of woody shrubs and other associates of *chir* and are well sheltered by the branches and leaves of woody dicotyledons. They remain viable during the earlier part of the monsoon. It is difficult to deal with these spores effectively. It has been observed that the æcidial sori continue to appear and discharge spores even during the late summer that is, the end of July. The infection of *Swertia* occurs through these spores. The burning down of the early summer spores does not help in the control operation very much and it is not possible to carry out this burning till late in the season when the forests become sufficiently dry.

(v) During several years of field study, the writer noticed that most of the trees which appeared in an unmistakably moribund condition between October to February bore æcidial sori in the following season. A good many of them, at least, which were likely to produce the æcidial stage could be easily recognised in early spring and marked by a responsible officer. Such trees, if removed before spring, *i.e.*, before the æcidiospores are produced, would naturally minimise the chance of spore dissemination. Secondly, it is less probable that the æcidial spores will over-winter and still less that the mycelium will remain active and fructify in the next spring if the diseased pines are felled in autumn and are removed outside the compartment and finally left unburnt. Consequently the burning of these trees with the object of destroying the æcidial stage which may be produced on them after they are cut down is really superfluous.

(*f*) *Eradication of Swertia and suppression of teleutostage.*— Without going much into the details of the merits of this method of control which is already well-known as one of the most effective methods of dealing with heteroecious rusts, let us consider how best this can be done. In enacting this measure one has to guard against the following contingencies.

(i) The eradication of *Swertia* host should proceed during the monsoon when the plants are easily recognisable in the field and before the teleutostage appears on them. This method should be completed before the capsules are mature, *i.e.*, middle of October. The life-history of *Swertia* plants has been described in full and the approximate dates in their life-history have been given in sections IV and VIII(*d*).

(ii) If the facilities for carrying out such a campaign, *viz.*, labour, etc., are not available during the rainy months, this operation should start immediately after the monsoon, by the middle of September and should be continued till the middle of December. The seeds begin to mature from October, depending on the nature of the locality, and the capsules open out from the middle of October to disperse the seeds and continue dispersing them till the end of December.

(iii) In the later case, that is, if the eradication operation is started in autumn, special instruction should be given not to unnecessarily shake the plants, nor to leave them on the ground after they have been cut for any length of time before final removal. A single day's sunshine will dry up any already mature capsules and discharge the seeds on the spot if the plants be left there for any length of time.

(iv) These species of *Swertia* which are prevalent in the *chir* forests of Kumaon and Garhwal and are connected with the pine disease have no economic value. There is one species, however, *S. chirata* which is taller and has longer and broader leaves than the rest, that is used as a preventive medicine for malarial fever. The other species, specially *S. purpurescens* and *S. alata* are often used to adulterate the marketable *S. chirata*, the rate of admixture varying from 20 to 40 per cent. Otherwise, the above five species are of practically no economic importance. The plant has no value as fodder. When, as is generally the case in infected plantations, it grows scattered all over the infected compartment and elsewhere as small fields mixed with forest grasses, it may be removed along with fodder grasses if the grass cutting is done in September and finished by October. But if this is done later in the season, the mature seeds would be dispersed more widely through this operation as already explained.

(v) Of the five species of *Swertia* found in Kumaon, namely, *S. alata*, *S. angustifolia*, *S. cordata*, *S. paniculata* and *S. purpurescens*, the first three only are susceptible, as has been proved by inoculation experiments and natural infection, but it is perhaps not safe at the present time to select only these species during the eradication operations as, firstly it will be difficult for untrained labourers to identify the susceptible species from the immune species; and secondly, it has been observed that in the absence of the susceptible host an immune species adapts itself to be a moderately receptive host after a certain time. The writer noticed in the Chakargaon plantations, West Almora, during his subsequent tour in November 1929, *S. angustifolia* var. *pulchella* and several plants which resembled *S. angustifolia* so far as the specific characters are concerned, but with purplish flowers and stem and leaves, apparently a hybrid, which were also heavily infected with *Cronartium himalayense*.

(vi) The eradication of *Swertia* from the infected compartment should be complete first and then the operation should be extended further up to the range of spore dissemination already discussed under section VI (*d*). As every forest range may have its own difficulties, a programme should be drawn up for each range and every compartment should be allowed a three years' term of eradication which may be followed by alternate years up to the ninth year, so that each compartment and its vicinity will have six eradication years by that time. Or even two years eradication operation followed by alternate years up sixth operation may be prescribed, which will be less expensive.

(vii) In connection with the operation of the eradication of the *Swertia* host the writer has the following experience. In October 1927, when *Cronartium himalayense* was first discovered 386 plants of *S. alata* were collected in several instalments from the Kaligadh block, compartment 2, for the purpose of inoculation experiments and seed collection. In October 1928 when orders were issued to send a consignment of *S. alata* to Dehra Dun for seed collection, 191 plants in all were procurable. In October 1927, the writer removed 1,826 plants of *S. angustifolia*, 830 of *S. cordata* and 316 of *S. purpurescens* from Kalimat compartments 1 and 3. It was also noted from the above block that *S. purpurescens* was in much greater number than *S. cordata* and *S. cordata* than *S. angustifolia*, but a less number of plants of the former two species were collected as they did not bear the *Cronartium* fungus and consequently were of no use for inoculation purpose. In July 1928, 106 plants of *S. angustifolia*, 40 of *S. cordata*, which were then just appearing in that forest and were about 1 to 4 inches in height, were collected. From the 1st October till the 20th December of the same year 810 plants of *S. angustifolia* and 412 of *S. cordata* were procured after a long and careful search from the two compartments of Kalimat block. This shows a considerable decrease in number and the above species were becoming fewer every year as they were removed in large numbers during the previous years from Kalimat forests. From a plot in Khabodi South block in Garkhet range 1,173 plants of *S. angustifolia* were collected in 1927 and a report of noticeable decrease of the species was received in 1928. In the year 1929 the writer who twice examined all the above mentioned infected blocks from June till the middle of November for further field work and for conducting inoculation experiments of *chir*, met with considerable difficulty in procuring susceptible species from the infected compartments in the above three localities where *Swertia* had grown in profusion during the previous years. The small fields of *Swertia* which usually occur with 10 to 100 plants and which can be noticed from a distance seemed to have been become rare and one had to look through the grass floor of these forests more closely for isolated specimens which were here and there concealed in the tall grass.

(viii) Although a cent. per cent. removal of *Swertia* is not possible by hand eradication, the removal of the larger plants will so reduce the seed crops as to be fully effective when repeated a few times.

(ix) Fire-lines from which grass is removed annually or burnt every year and are sometimes heavily grazed by cattle should not be considered free from infected *Swertia*. It has been mentioned in Chapter III (*b*) that *S. angustifolia* and *S. alata* with heavy infection of *Cronartium* were frequently noticed on the fire-line from which the pines were apparently receiving infection. The other species of *Swertia* which have been described as apparently immune were also very common in these places. The *Swertia* plants collected from the fire-lines during the different tours show certainly a dwarfed or bushy appearance (Plate IV, figs. 1, 2, 3 and 4) and are not so tall as those growing in the forest and one has therefore to examine the ground more closely to detect them.

(x) As regards the agencies which help in distributing the *Swertia* host, we have two factors to consider, that is, the wind and the rain. From the experience of three successive years' field study, it seemed that *Swertia* does not change its 'field' very often. They were seen on the same slope for three years in succession. From the nature of the seeds, wind does not seem to play any part in distributing them very far though it may help in their local dispersal to a certain extent. But they are certainly carried by the water currents to some distance, depending on the nature of the forest and its contour. Consequently, before repeating the eradication operation in the following year, it is advisable that a survey of the infected area should be done and eradication area should be plotted out every year.

In conclusion, the writer, having examined all the known methods of control, both silvicultural and pathological, is practically left with no other choice than the two well-known eradication methods of control discussed above. Of the silvicultural methods, the substitution of *chir* with *P. khasya*, in suitable localities, the admixture of *chir* with other broad-leaved species ordinarily associated with it and the advantage of selection system of *chir* regeneration are points which deserve some consideration. The observation indicates that young regeneration of *chir* should be protected from fire as it causes adventitious budding and forces them to produce a great number of primordial needles which again serves as the channel of entry of this desease.

The disease is to be controlled in the first place by carefully destroying the diseased trees. Every diseased pine left standing is a source of indirect infection in the neighbourhood and a menace to the young stand. Every care should be taken to burn the spores and such measures should be adopted which will reduce their dissemination to the minimum during such operations. This operation should be started early in spring and continued throughout summer till the monsoon, if possible. It has been noted that the æcidiospores which are produced late in the season are most effective in infecting the second host and they remain in a viable condition longer. These spores are not always visible to the unaided eye, some of them become bleached by rain and the sun and lose viability but a great number continue to infect *Swertia* during and after the monsoon. Unless these are completely destroyed, they remain a source of danger for a long time.

The second method consists primarily in suppressing the teleutostage, and finally, eradicating the alternate host. The success of this method lies in eradicating the *Swertia* host before the teleutostage appears, and secondly in completely eradicating *Swertia* before the seeds are mature and are dispersed from the capsules. This disease is only perpetuated through the medium of the second host. It is not likely that this rust hibernates or overwinters in this country on the felled branches and trees of pine in the æcidial stage or on the dead and decomposed parts of *Swertia* in the uredostage. It is a matter of doubt if the æcidiospores would retain their viability till the next year and infect the young *Swertia* during the rains and it appears still more doubtful that the uredospores will remain on any part of the plant in spring and infect the pine. It is extremely doubtful that this disease is transmitted through the seeds of pine in the æcidial-form as no cone has ever been noticed to bear this fungus nor that the uredostage may be transmitted through *Swertia* seeds. The inheritance of such disease, through seed, has not been proved so far, in case of any rust which is strictly heterœcious.

The eradication of the alternate host in case of various heterœcious fungi, specially in the case of wheat rust, has proved a great success in controlling this pest. Such a measure as a control for the blister rust of white pines has been carried out in the United States of America, in Canada and in Central Europe in Germany, Switzerland, Austria and Hungary, Norway and Sweden and in the United Kingdom. In spite of many difficulties which the United States and Canadian Governments had to contend with in enacting the control measures of the white pine blister rust, namely, the perennial nature of the alternate host (*Ribes*), the phenomenon of overwintering on the pines as well as on the *Ribes*, combined with the economic importance of *Ribes* and the distribution of various species of native pines some of which are highly susceptible to *Cronartium ribicola* infection, they were forced to enact quarantine laws prohibiting the transhipment of *Ribes* from the infected to the uninfected, eradicated and controlled provinces. They have succeeded in reducing the infection and in bringing the disease under control. The *Swertia* species, which are now known as the alternate hosts of the *chir*-pine blister rust, are annual herbs and as infection takes place every year, such contingencies do not arise. Consequently, we have, even though the disease has established itself and appears to be wide-spread throughout the young pine stands in the North and North Western India, an easier problem to work out in bringing this pest under control.

X. SUMMARY.

2. The blister rust disease on *Pinus longifolia* has fully established itself in the pine forests of the Kumaon and Garhwal Himalayas. The disease has a much wider distribution than has been found in other regions of the Himalayas where pine grows either gregariously or mixed with other species. The amount of damage cannot at present be estimated in figures but must be very high. All attempts to control this disease have hitherto failed. Owing to the high rate of mortality of young saplings, wide gaps have been formed in the plantations of the Almora Forest Division and attempts to fill them up by occasional sowings have failed. This disease has also affected much young natural regeneration in the Almora, Garhwal and Naini Tal Forest Divisions. The blister rust disease generally affects young crops up to 20 years of age. Trees beyond 30 years of age appear safe from infection.

2. In the course of a search for the alternate stages a species of *Cronartium* was discovered in Kaligadh block, Ranikhet, in October 1927 on *Swertia alata* and in Kalimat, Almora, on *S. angustifolia* and on *S. cordata*. The search was extended over 45 blocks consisting of about 200 compartments of Kumaon Forest Circle (Almora, Garhwal and Naini Tal Divisions) and this fungus was found in all blocks where *chir* mortality was reported. There are two other species of *Swertia*, *viz.*, *S. paniculata* and *S. purpurescens*, which though always growing close to the three infected species bore no fungus.

3. The new species of *Cronartium* has been described as *Cronartium himalayense* and the full technical description has been included in the body of the paper.

4. During 1928 and 1929 the above five species of *Swertia* were inoculated under control with the æcidiospores of the blister rust previously described as *Peridermium himalayense* (3) from the stem of *P. longifolia* with the result that within two weeks the *Cronartium* stage was reproduced on them. *S. alata* and *S. angustifolia* took heavy infection and *S. cordata* took a slight infection but *S. purpurescens* and *S. paniculata* took no infection under the same circumstances. This fungus on *Swertia* spp. therefore is proved to be biologically connected with *Peridermium himalayense.*

5. The life history and distribution of the alternate hosts of this pine rust, *viz.*, of the above mentioned species of *Swertia* in the Himalayan and Sub-Himalayan tracts of North and North-Western India, have been described. The presence of this host has been recorded from practically all the forests where *P. longifolia* grows. The wide-spread infection of pine in these forests has therefore been correlated to the

widely distributed susceptible species of *Swertia* and all evidence seems to indicate that the long distance spread of this disease has been caused by wind-borne æcidiospores.

6. An attempt has been made to outline the history of blister rust on *P. longifolia* and its recent spread in the forests of the Almora, Garhwal and Naini Tal Forest Divisions. The introduction of the blister rust to new areas has been explained, so far as the available data at our disposal permit, to be due to wind-blown æcidiospores, which infect the broad-leaved host during the early monsoon rains, and the re-infection of pine by sporidia from the germinating teleutospores takes place at close range during the later part of the monsoon and sometimes continues till autumn. The approximate time when the infection of both hosts takes place in nature has been given.

7. This paper deals with the dissemination of æcidiospores, uredospores, teleutospores and sporidia from various aspects. The æcidiospores of *Cronartium himalayense* are dry, dusty and powdery. They are produced in enormous quantities, like the wind-blown pollen of coniferous plants, and are capable of long-distance dissemination by wind. The uredostage is a local intensification stage and a repeating stage. The spores are often disseminated from one leaf of *Swertia* to another and sometimes from one group of *Swertia* plants to another and under warm and moist weather conditions produce an abundance of lesion locally. The teleutostage may be regarded both as an emergency stage and a multiplication stage, whereby the fungus produces a large surface of sporidia-producing cells just prior to the death of the host plant. In this form the fungus reaches its final and critical stage. These spores are of delicate structure which signifies their capacity of limited and local dissemination. Their chief function lies in the re-infection of pine to complete the cycle.

8. The "effective range" of spore dissemination and longevity of the above four kinds of spores have also been considered and a tentative range of pine and *Swertia* infection has been recorded. The problem of the overwintering of the various spore-forms of the fungus has been discussed. From the nature of the weather conditions under which the fungus spreads in these sub-tropical Himalayan forests the æcidiospores do not appear likely to overwinter. The broad-leaved host on the other hand is an annual; there is, therefore, still less likelihood of its overwintering in the uredo-form. The relation of weather conditions, *i.e.*, rain-fall, which is a factor controlling humidity and temperature during the infection period has been correlated to various degrees of infection of *Swertia* and the production of uredo and teleutostages for three years during which this investigation was continued.

9. Various methods of silvicultural treatment, which are generally prescribed for the control of heteroecious coniferous rusts, *viz.*, the substitution of the susceptible pine with other immune or less-susceptible native of foreign species of pine in these areas, the adoption of the Selection System of forest management, the admixture of broad-leaved species of forest trees with pine, have been discussed. But these propositions have been dismissed on account of considerable difficulties that would have to be faced in forest management, exploitation and economy of this species and of the unsuitability of other species of pine from a silvicultural point of view.

10. In the uniform regeneration system the area under young growth should be broken up as far as possible by older crops. This should serve as a natural control and check the spread of the disease when it attacks the regeneration in epidemic form.

11. Eradication of the alternate host is recommended as the only suitable measure to deal with this disease effectively. The destruction of the æcidiospores by burning the infected pines, which has been already tried in the Almora plantations without much success has also been fully considered. The range of æcidiospore dissemination has been tentatively determined to be 300 yards so that a strip of this width round infected pine stands should be kept free of *Swertia*. A scheme has been suggested for the eradication of *Swertia* spp. for three years in succession and thereafter in alternate years for six eradication years in Periodic Block I areas. The best time for eradication operations is soon after the rains till early autumn, before the *Swertia* seeds mature and are dispersed.

12. The divisional authorities may find it somewhat difficult to apply the above method of control but the writer believes it would be worth the trouble.

Acknowledgments.—The writer records his obligations to Mr. H. G. Champion, I.F.S., Silviculturist, Forest Research Institute, Dehra Dun, and to Mr. P. C. Kanjilal, I.F.S., the then Working Plan Officer, Naini Tal, for advice on matters of silvicultural technique; to Mr. R. N. Parker, I.F.S., formerly Forest Botanist, to Mr. C. E. Parkinson, Forest Botanist and to Dr. R. M. Gorrie, Honorary Editor, Indian Forester, for editorial corrections; to Messrs. J. E. C. Turner, I.F.S., and Hira Singh, P.F.S., Divisional Forest Officers, West Almora Division, for facilities for experimental and field work. Mr. Turner has also supplied the writer with the photograph of Chakargaon *chir* plantations reproduced in Plate V. The writer is also indebted to the Imperial Mycologist, Agricultural Research Institute, Pusa, and his staff for help given while working in his laboratory and herbarium in connection with this work. Thanks are also due to Mr. Ganga Singh, Artist, in the

Forest Botanist's office, for the drawing of *Swertia alata* reproduced in the frontispiece and Plate I.

XI. LITERATURE.

1. Annual Progress Report of Forest Administration in the United Provinces, 1927, 28 p.

2. Arthur, J. C. . . North American Flora, Vol. VII, Part 10, pp. 694-695, 1925.

3. Bagchee, K. D. . . Investigations on the Infestations of '*Peridermium complanatum*', Barclay on the needles, and of *Peridermium himalayense* n. sp., on the stem of *Pinus longifolia*, Roxb. Ind. Forest Records, Bot. Ser., Vol. XIV, Part 3.

4. .... A new species of *Cronartium* from the Himalayas, Nature CXXIV, 3131, pp. 691-692, 1929.

5. Barclay, A. . . A Descriptive List of the *Uredineae* occurring in the neighbourhood of Simla. Journ. of the Asiatic Soc. of Bengal, No. II, pp. 101-102, 1890.

6. Beeson, C. . . Death of *Chir* in Almora, Ind. Forester, Vol. XLVIII, pp. 342-343, 1922.

7. Champion, H. G. . Notes on Death of *Chir* (*P. longifolia*) Poles in the Almora Plantations of Kumaon, Ind. Forester, Vol. XLVIII, p. 168, 1922.

8. Clinton, G. P. . . Artificial infection of *Ribes* species and White Pine with *Cronartium ribicola*, Amer. Plant. Pest Comm. Bul. 2, pp. 14-15, 1918.

9. Clinton, G. P. and McCormick, F. A. Infection Experiment of *Pinus strobus* with *Cronartium ribicola*, Conn. Agric. Expt. Sta. Bull., pp. 428-459, 1919.

10. .... Rust Infection of Leaves in Petri dishes, Conn. Agri. Expt. Sta. Bull. 260, pp. 475-501, 1924.

11. Colley, R. H. . . Parasitism, Morphology and Cytology of *Cronartium ribicola*, Journ. Agri. Resch., Vol. XV, No. 12, p. 619, 1918.

12. Duff, George H. . Some factors affecting viability of the urediniospores of *Cronartium ribicola*, Phytopath., Vol. VIII, No. 6, pp. 289-292, 1918.

13. Hooker, J. D. . . Flora of British India, Vol. IV, pp. 121-130.

14. Hahn, Glenn Gardner The Inoculation of Pacific North-Western *Ribes* with *Cronartium ribicola* and *C. occidentale*, Journ. of Agri. Resch., Vol. XXXVII, No. 11, pp. 663-683, 1928.

15. Hunt, N. R. . . The "iceless refrigerator" as inoculation chamber, Phytopath., IX, pp. 211-212, 1919.

16. Klebahn, H. . . Die Wirtswechselnden Rostpilzen XXXVII, 447 p. Berlin, Literature P. IX-XXXVII, 1904.

17. .... Kulturversuche mit Rostpilzen. In Atschr· Pflanzenkrank, Bd. 15, Heft 2, pp. 65-108, 4 fig., Pl. 3, 1905.

18. Meinecke, E. P. . . Facultative Hetroecism in *Peridermium cerebrum* and *Peridermium harknessii*, Phytopathology, Vol. X, p. 282, 1920.

19. McCubbin, W. A. . Dispersal distance of urediniospores of *Cronartium ribicola* as indicated by their rate of fall in still air, Phytopath., Vol. VIII, No. 1, pp. 35-36, 1918.

20. Nisbet, J. . . . The diseases of trees, Ind. Forester, XXI, p. 132, 1895.

21. Pennington, L. H. . Relation of weather conditions to the spread of White Pine Blister Rust in the Pacific Northwest. Journ. Agri. Resch., Vol. XXX, No. 7, pp. 593-507, 1925.

22. Saccardo, P. A. . . Sylloge Fungorum, Vol. XXIII, Supplementum Universalle, Basidiomycetes. Pare X, pp. 808-915, 1925.

23. Snell, Walter H. and Rathburn-Gravatt, Annie.	Inoculation of *Pinus strobus* trees with sporidia of *Cronartium ribicola*, Phytopath., Vol. XV, No. 10, pp. 584-590, 1925.
24. Spaulding, P. . .	Investigations of the White Pine Blister Rust Bull. No. 967, 1922.
25.	White Pine Blister Rust. A comparison of European with North American conditions, Washington, 1929.
26. Rathburn-Gravatt, Annie.	Conditions antecedent to the infection of White Pines by *Cronartium ribicola* in the north-eastern United States, Phytopath., Vol. XV, No. 10, pp. 573-583, 1925.
27. Sydow von H. et p. .	Diagnosen neuer *Uredineen* und *Ustilagineen* nebst Bemerkungen zu einigen bereits bekannten Arten. Ann. Mycol., I, p. 21, 1903.
28. Troup, R. S. . .	*Pinus longifolia*, Roxb. A Silvicultural Study, Indian Forest Memoir, Vol. I, Part 1 (Introduction).
29.	Silviculture of Indian Trees, Vol. III, p. 1013, 1895.
30. Turner, J. E. C. .	Slash in *Chir* Pine (*Pinus longifolia*) Forests, Ind. Forest Records, Silvicultural Series, Vol. XIII, Part 7, 1928.
31. York, H. H. and Spaulding, P.	The overwintering of *Cronartium ribicola* on *Ribes*, Phytopath., Vol. VIII, No. 12, pp. 617-619, 1918.
32. York, H. H. and Snell, W. H.	Experiments in the Infection of *Pinus strobus* with *Cronartium ribicola*, Phytopath., Vol. XII, p. 148, 1922.

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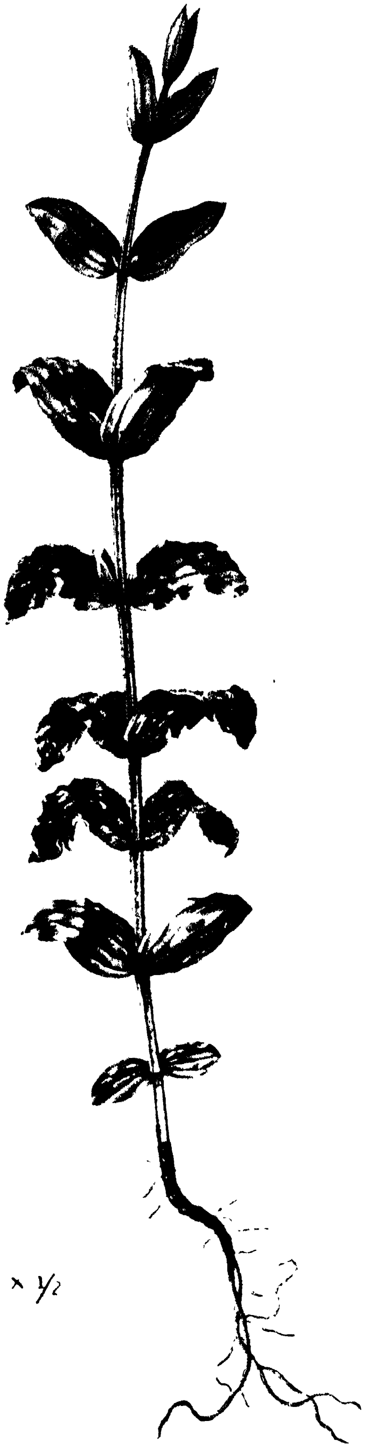
EXPLANATION OF PLATE I.

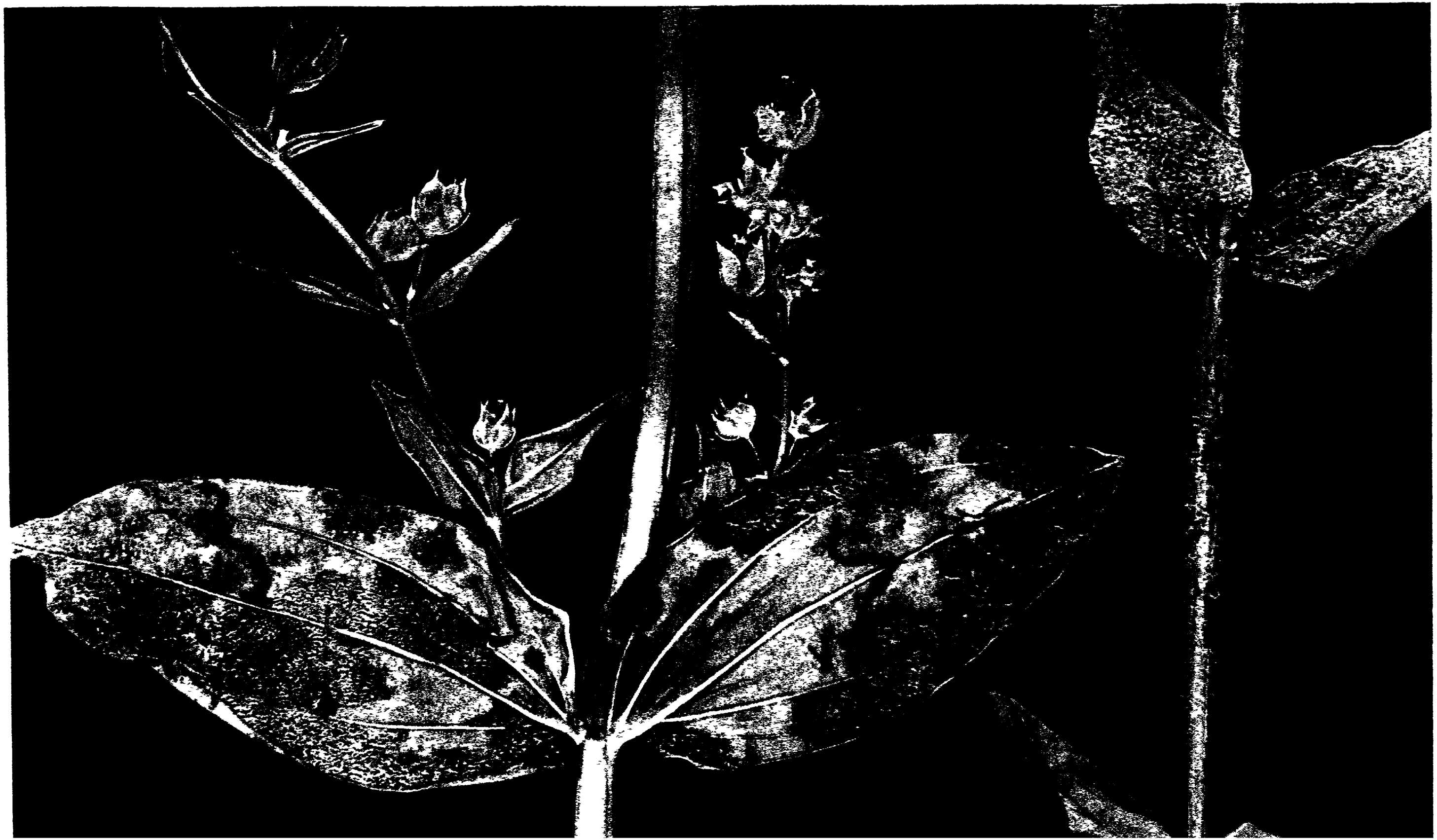
Drawing of *Swertia alata* illustrating in a semi-diagrammatic manner the succession of *Cronartium* infection of the leaves during the progress of the rust. × ½.



× 1/2

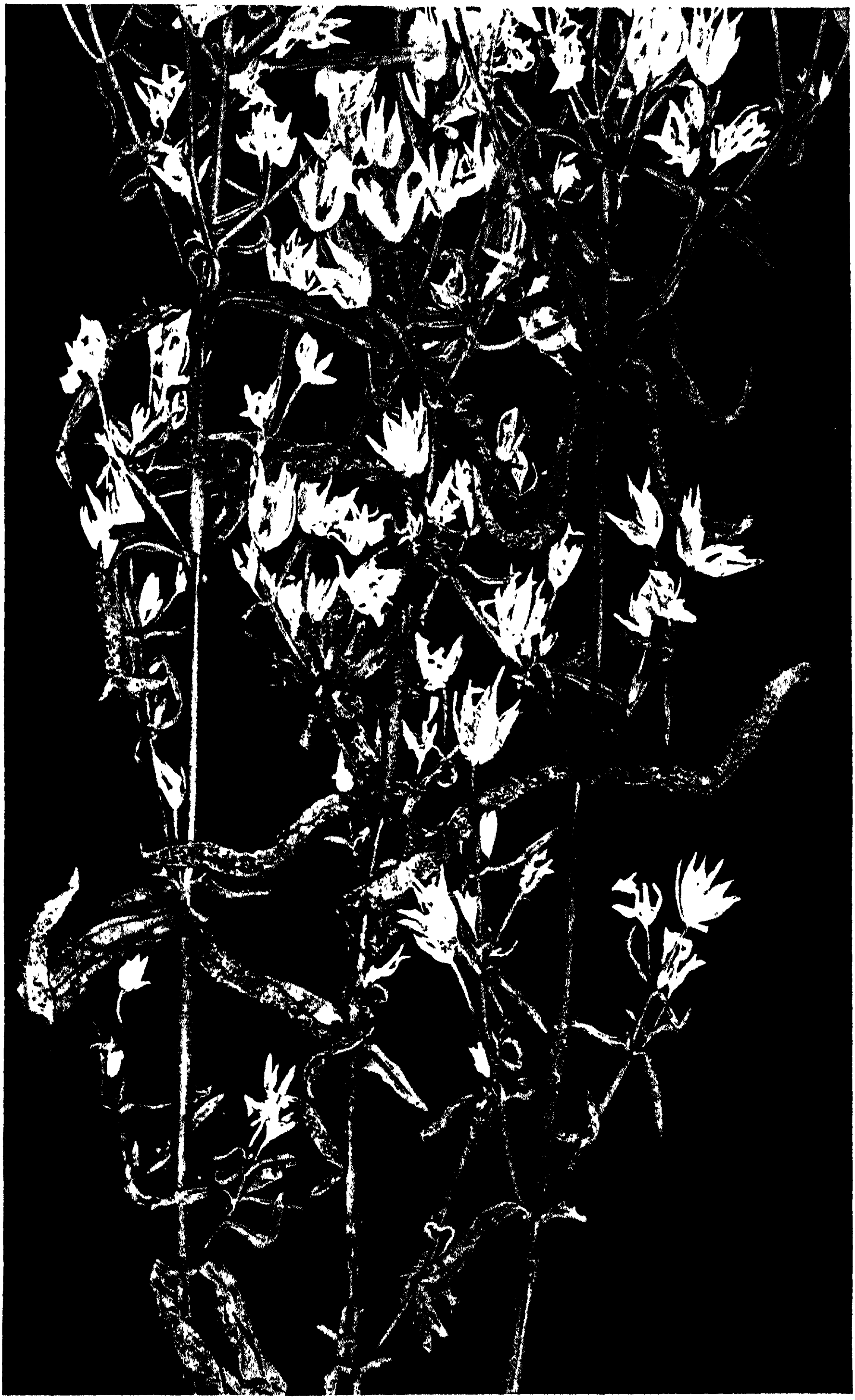
EXPLANATION OF PLATE II.

Photograph of a pressed specimen of *Swertia alata* from Kaligadh compartment, Ranikhet, West Almora Division, with typical infection of *Cronartium himalayense*. ×4.



EXPLANATION OF PLATE III.

Photograph of a pressed specimen of *Swertia angustifolia* from Kalimat compartment, Almora, West Almora Division, with typical infection of *Cronartium himalayense*. ×4.



EXPLANATION OF PLATE IV.

Photograph of pressed specimens of three dwarfed species of *Swertia* from the fire-lines and grazed forests. Figs. 1 and 2 *Swertia angustifolia* from Garkhet and Chakargaon blocks, West Almora Division; Fig. 3 *Swertia alata* from Pharkanouli block, West Almora Division; Fig. 4 *Swertia cordata* from Bhowali block, Naini Tal Division. × ⅓.

FIG. 1

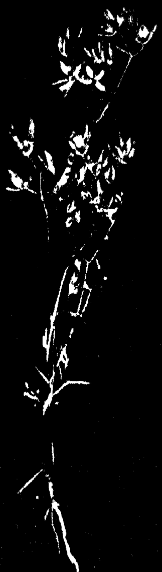


FIG. 2

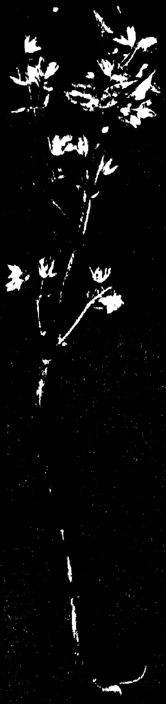


FIG. 3

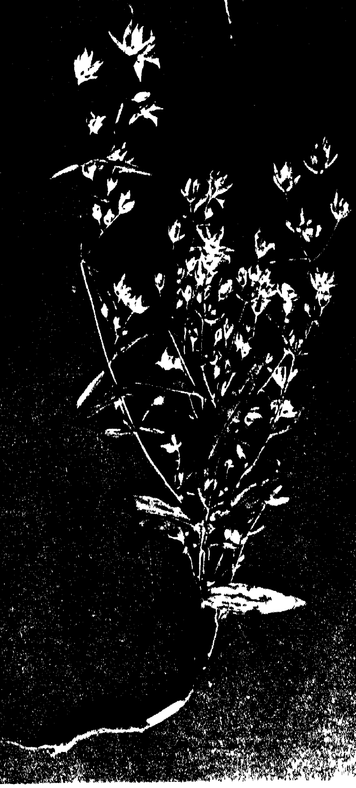
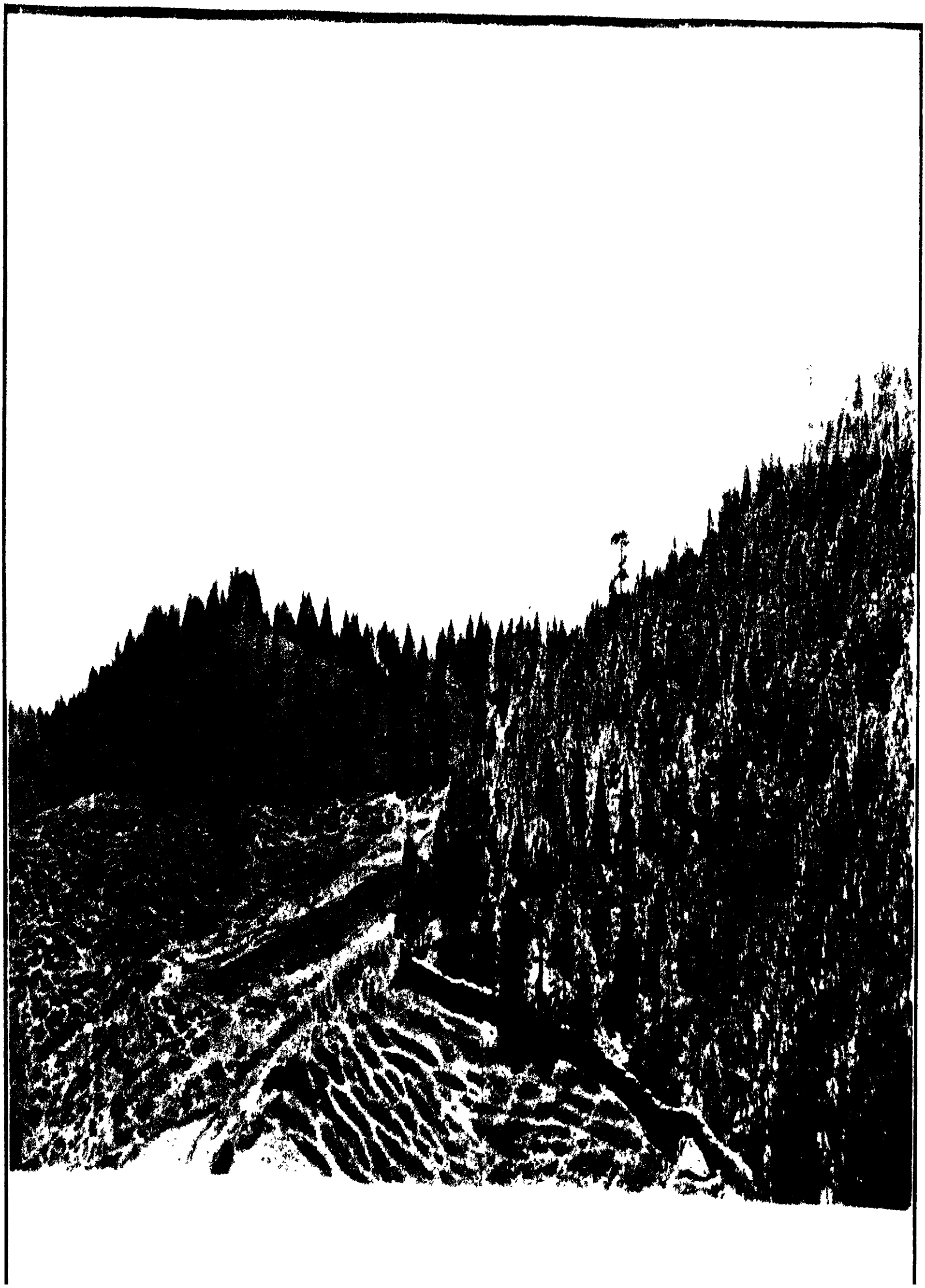


FIG. 4

EXPLANATION OF PLATE V.

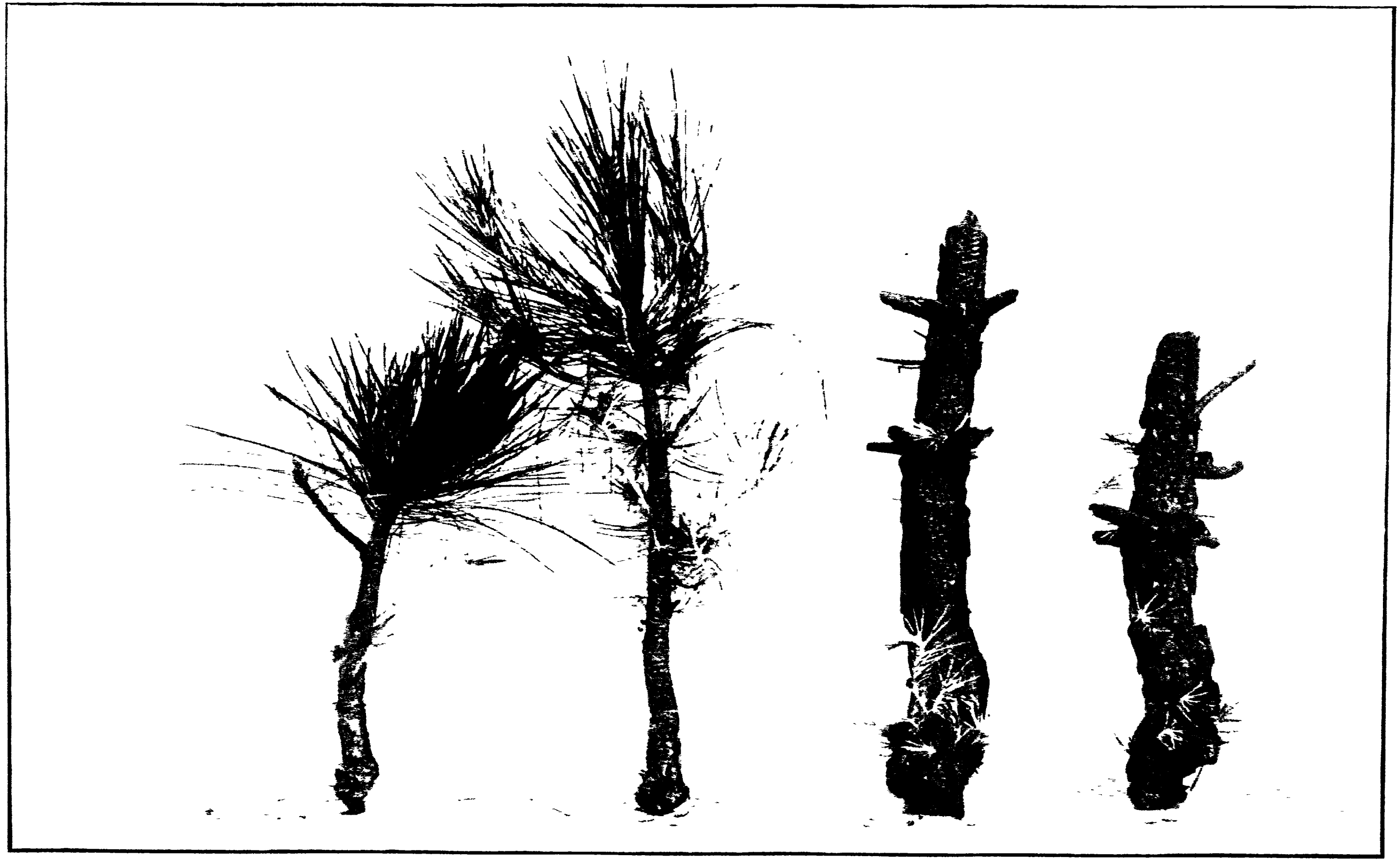
Photograph of *chir* forest showing typical gaps caused by the *Cronartium* mortality (left) with some dead trees in the fore ground as compared with the well-stocked forest in the right-hand side of the picture. Chakargaon plantations, West Almora Division.



EXPLANATION OF PLATE VI.

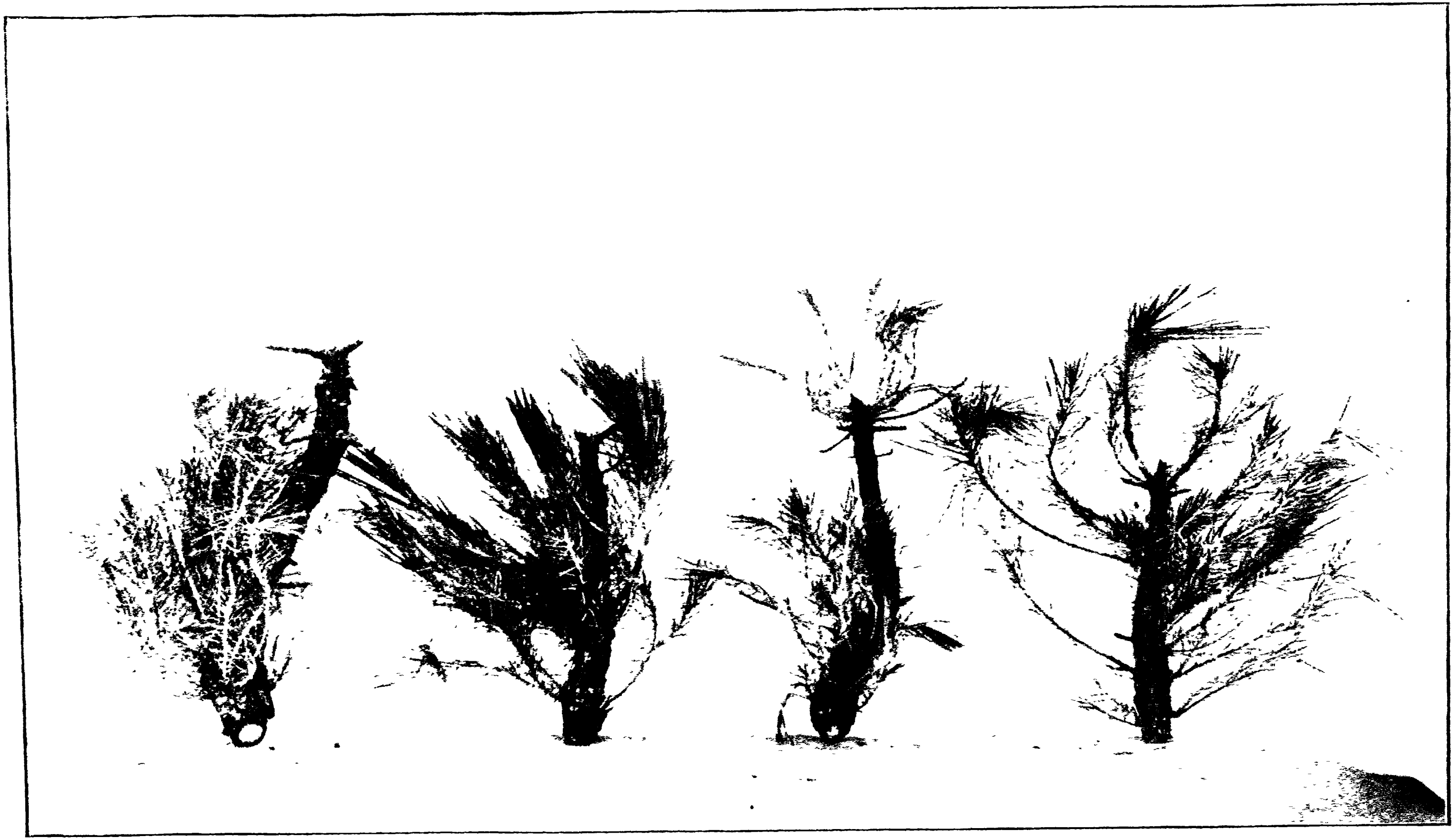
Photograph of specimens of saplings of *Pinus longifolia* of different ages from 4 to 7 years from Pharkanauli Controlled Burning Experimental Plot No. C, West Almora Division, the area being burnt once every year. Note the amount of primary needle-like tufts produced from the leading stem. Photographed in November. 1929.

PLATE VI



EXPLANATION OF PLATE VII.

Photograph of specimens of saplings of *Pinus longifolia* of different ages from 4 to 7 years from Pharkanauli Controlled Burning Experimental Plot No. D, West Almora Division, the area being burnt twice every year. Note a number of coppiced shoots, the foliage consisting mostly of primary needles. The leading branches have died due to damage from fire. Photographed in November, 1929.



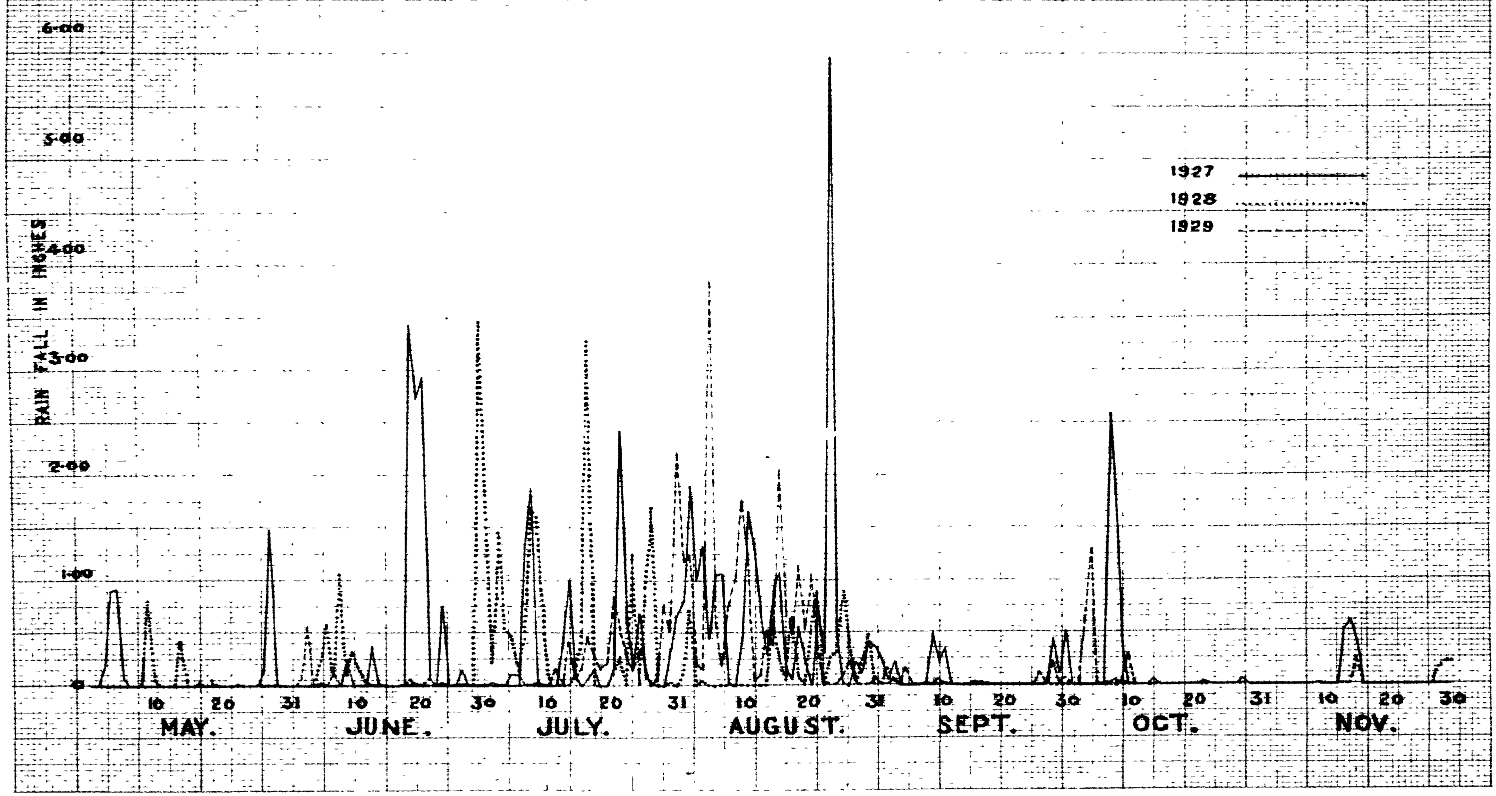
EXPLANATION OF PLATE VIII.

Photograph of a section of a leading stem of *Pinus longifolia*, showing a number of adventitious buds produced artificially in the course of three years by tightening a galvanised iron wire round the stem; age of the tree 7 years. Note the cut ends of the wire in the right-hand side of the photograph. × ¼.

EXPLANATION OF PLATE IX.

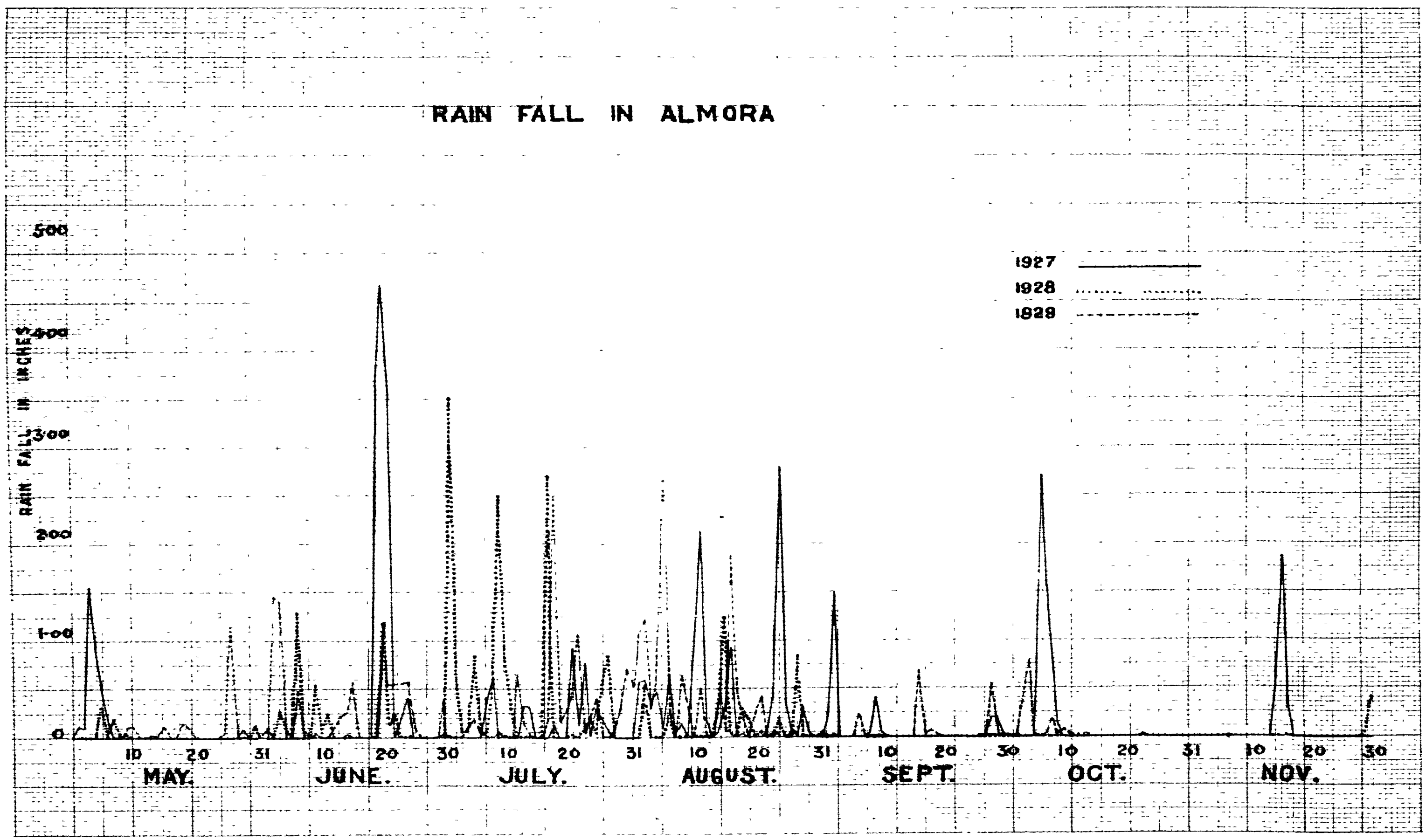
Chart showing rainfall curve of Ranikhet for the years 1927, 1928 and 1929.

RAIN FALL IN RANIKHET



EXPLANATION OF PLATE X.

Chart showing rainfall curve of Almora for the years 1927, 1928 and 1929.


RAIN FALL IN ALMORA
1927
1928
1829
RAIN FALL IN INCHES
500
400
300
200
1·00
0
10
20
31
10
20
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10
20
30
MAY.
JUNE.
JULY.
AUGUST.
SEPT.
OCT.
NOV.

EXPLANATION OF PLATE XI.

FIG. 1.—Drawing of a section of *Swertia alata* leaf through stomata showing a very early stage of infection of the fungus. The leaf portion was pickled 6 days after inoculation just when the etiolation of the disease was evident. Note the haustoria-like tip of the æcidiospore and sections of loose hyphæ in the sub-stomatal vesicle. The binucleate cells are arranged against the epidermis in a regular fashion; (*a*) haustoria-like cells. ×450.

FIG. 2.—Drawing of a median section of a very young uredosorus in the process of development. The section of the leaf was taken when the epidermis was slightly raised from the leaf-surface, 8 days after inoculation. Note the cells just below the epidermis are oriented with their long axes more or less perpendicular to the epidermis; (*a*) peridial cells, (*b*) young uredospores, (*c*) stalk cell, (*d*) basal cells, (*e*) epidermis. ×450.

FIG. 3.—Drawing of a tangential section of a young uredosorus somewhat older than that illustrated in the previous figure. Note the elongated nature of the young peridial cells; (*a*), (*b*) young uredospores, (*c*) stalk cells, (*d*) basal cells, (*e*) epidermis. ×450.

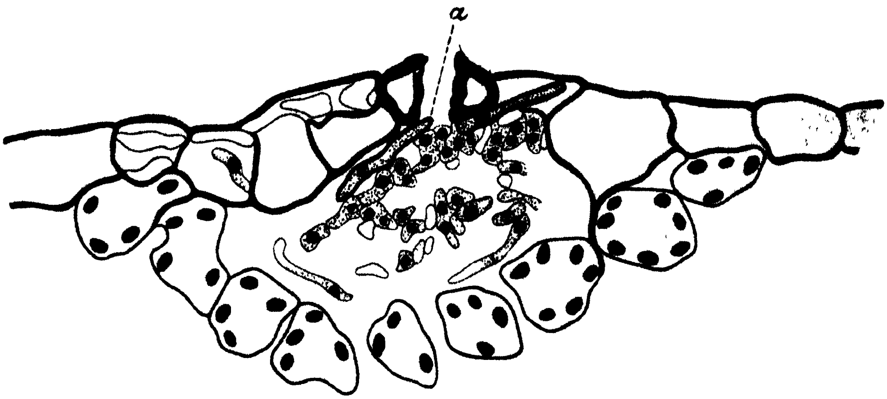


Fig. 1.

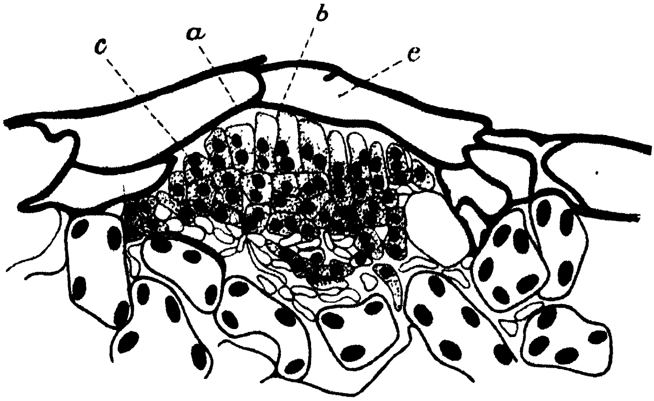


Fig. 2.

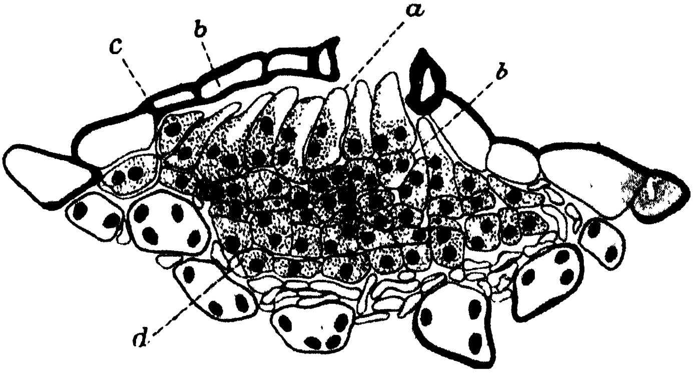


Fig. 3.

EXPLANATION OF PLATE XII.

FIG. 1.—Drawing of a median section of a young uredosorus slightly more advanced than that of Fig 3. Note the binucleate young uredospores and the disintegrating basal cells. The peridial cells are collapsing and note their early disintegration; (*a*) peridial cells, (*b*) young uredospores, (*c*) stalk cells, (*d*) basal cells, (*e*) epidermis. ×460.

FIG. 2.—Drawing of a median section of a mature uredosorus; (*a*) peridial cells, (*b*) uredospores, (*c*) stalk cells, (*d*) basal cells, (*e*) epidermis. ×460.

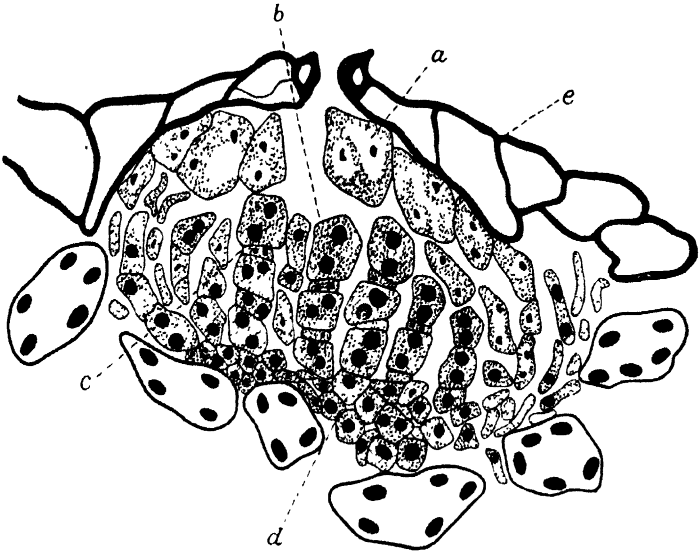


Fig 1

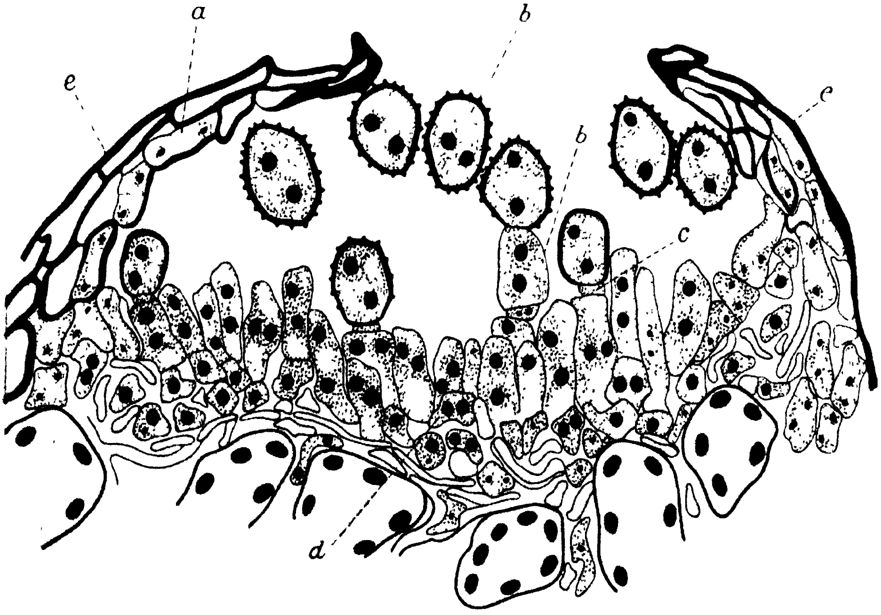


Fig. 2.

EXPLANATION OF PLATE XIII.

FIG. 1.—Drawing of a median section of a young teleuto-column which is produced through an old uredosorus. Note the change of configuration of the cells in transition. A few immature uredospores are seen in the diagram. The peridial cells have entirely collapsed; (*a*) peridial cells, (*b*) uredospore mother cells, (*c*) young teleutospores, (*d*) epidermis. ×460.

FIG. 2.—Drawing of a median section of a young teleutosorus. Note the broken and disintegrating peridium (*a*). ×460.

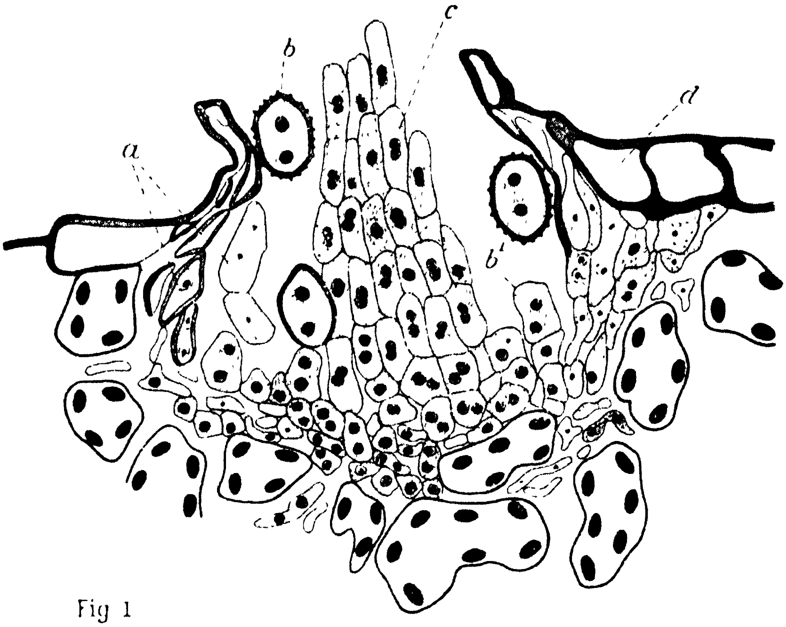


Fig 1

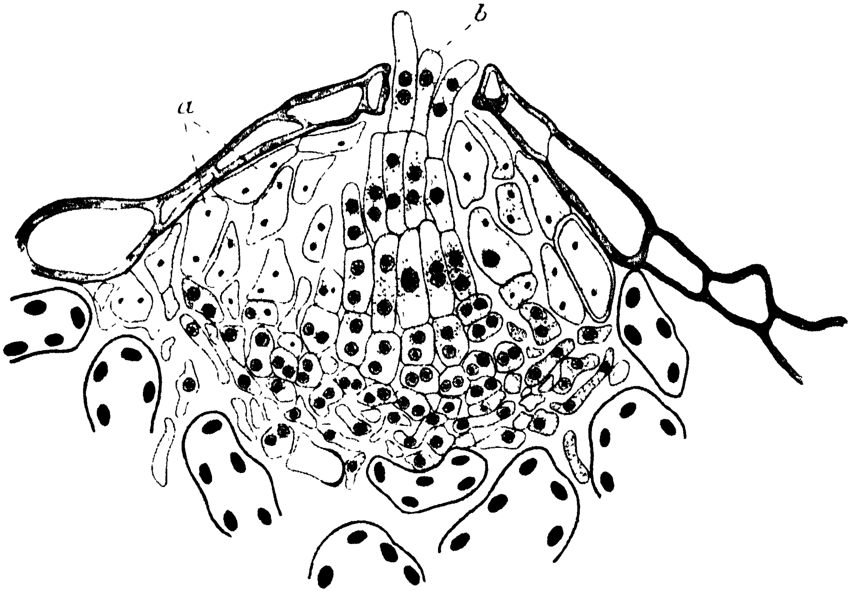
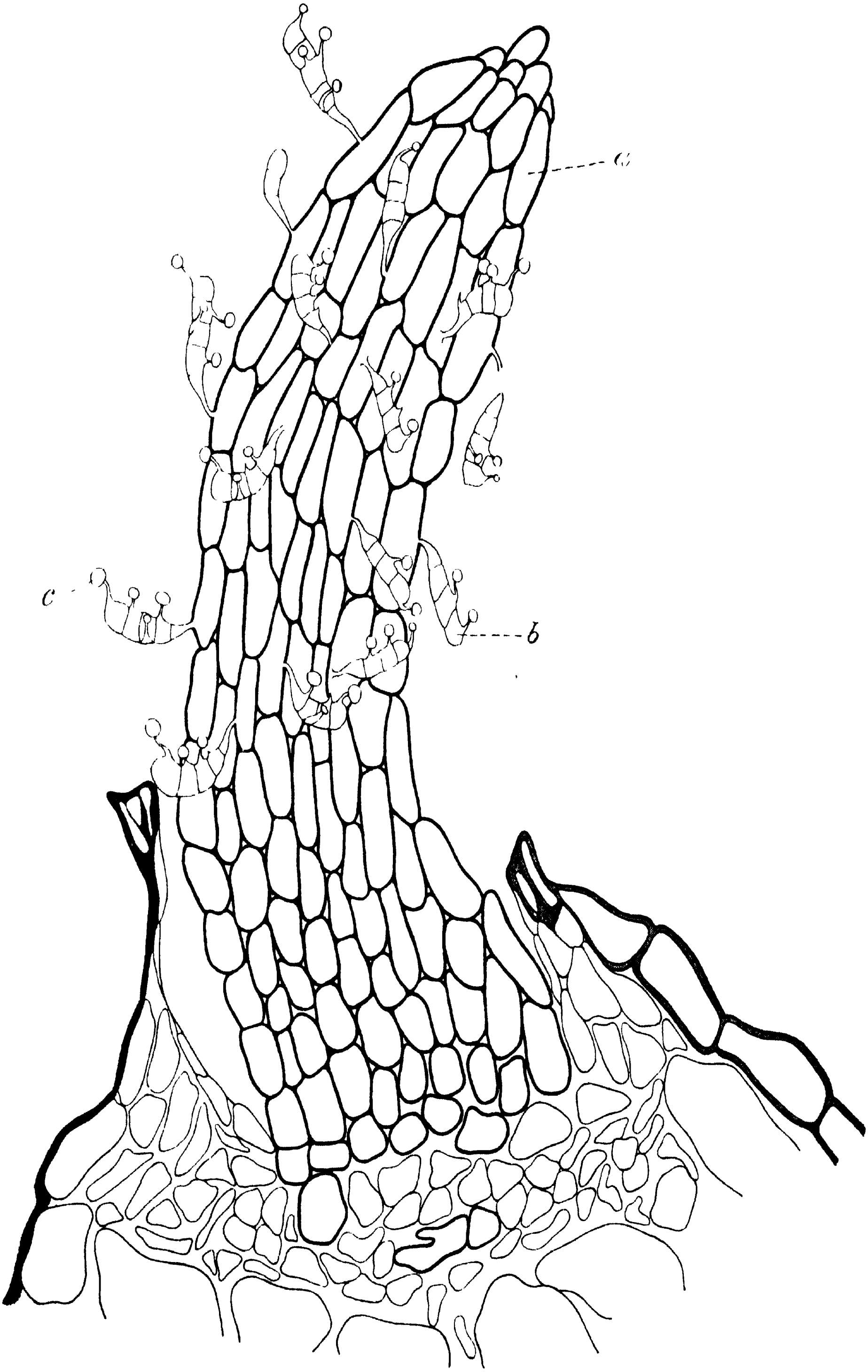


Fig 2

EXPLANATION OF PLATE XIV.

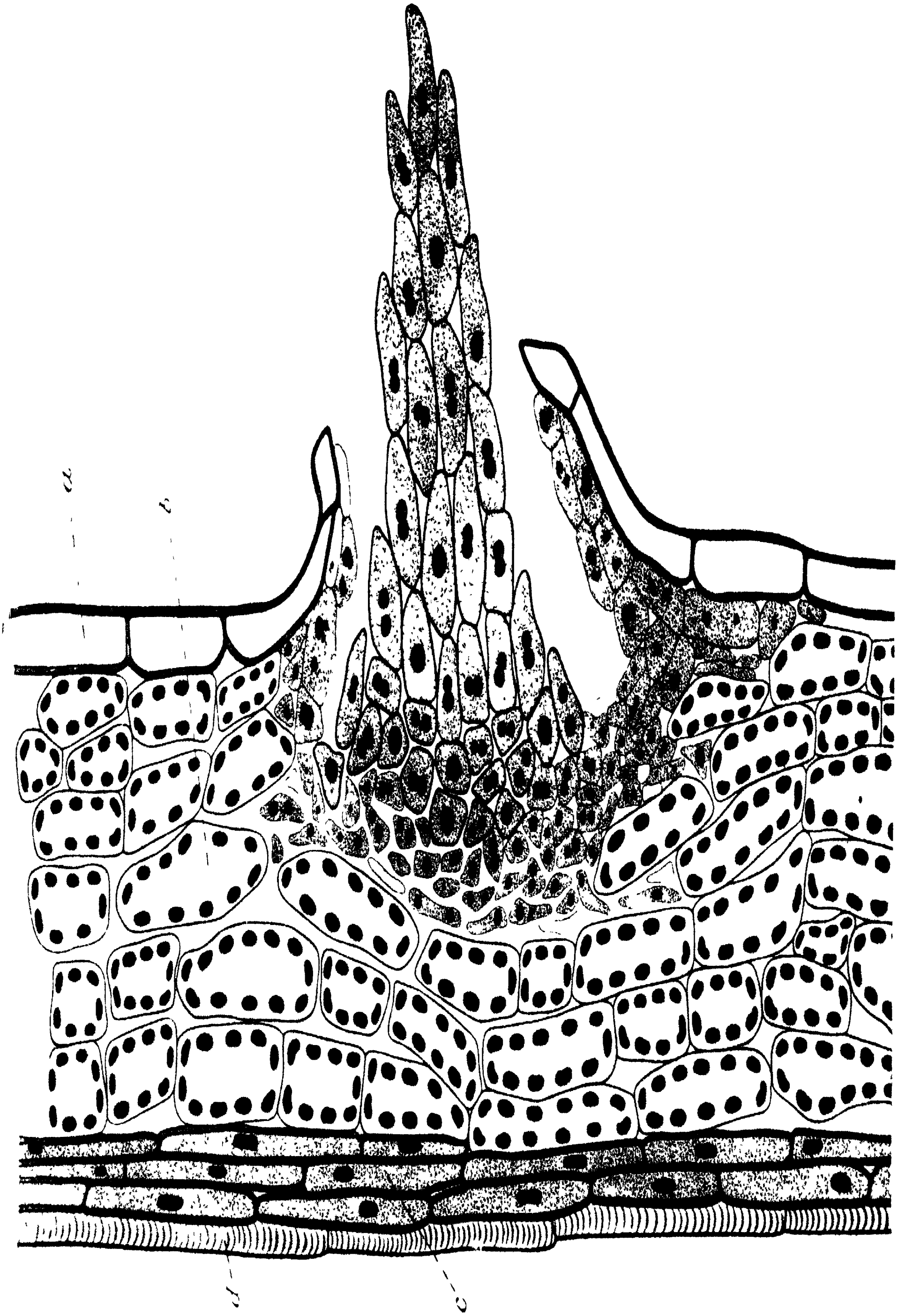
Outline drawing of a complete teleuto-column produced on the under surface of the leaf of *Swertia alata*. Note the germinating teleutospores (*a*) producing promycelia (*b*) and basidia (*c*). Semi-diagrammatic. ×540.

PLATE XIV.



EXPLANATION OF PLATE XV.

Drawing of a young teleuto-column from the stem of *Swertia alata*, showing only a portion of the stem; (*a*) epidermis, (*b*) parenchyma, (*c*) cambium, (*d*) vessels. Semi-diagrammatic. ×540.


a
b
d
c

EXPLANATION OF PLATE XVI.

FIG. 1.—Drawing of germinating teleutospores showing the earliest stage of knobby growth. × 840.

FIG. 2.—Drawing of germinating promycelium with the tip bearing sporidia. × 940.

FIG. 3.—Outline drawing of a promycelium, which has collapsed after the discharge of sporidia. × 840.

FIG. 4.—*a* and *b* stages during germination of æcidiospores. × 840.

FIG. 5.—A, B and C stages during germination of sporidia. × 1160.

FIG. 6.—*a* and *b* stages during germination of uredospores. × 1000.

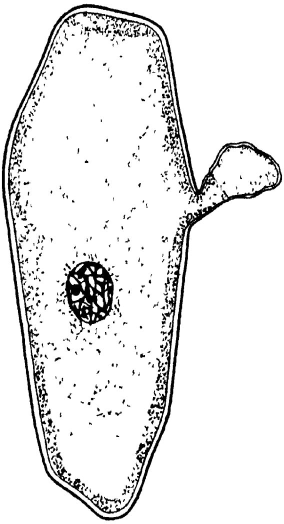


Fig 1.

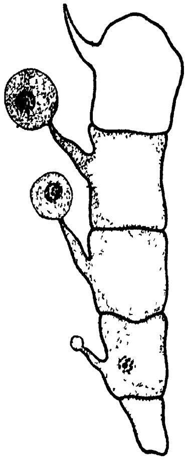


Fig. 2.

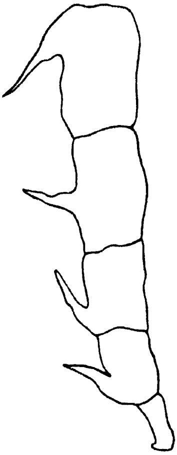


Fig. 3.

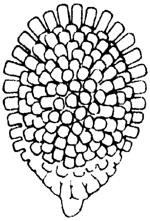


Fig 4 *a*

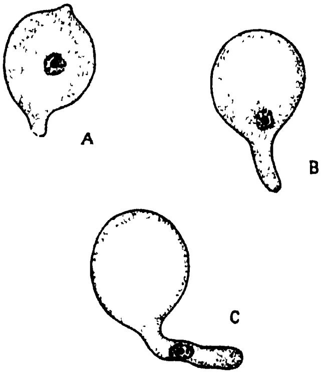


Fig 5

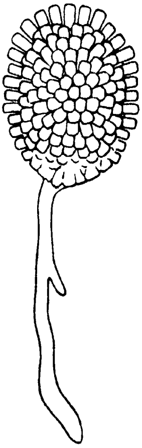


Fig. 4 *b*

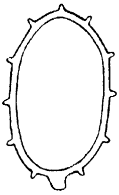


Fig 6 *a*

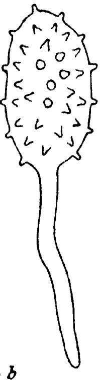
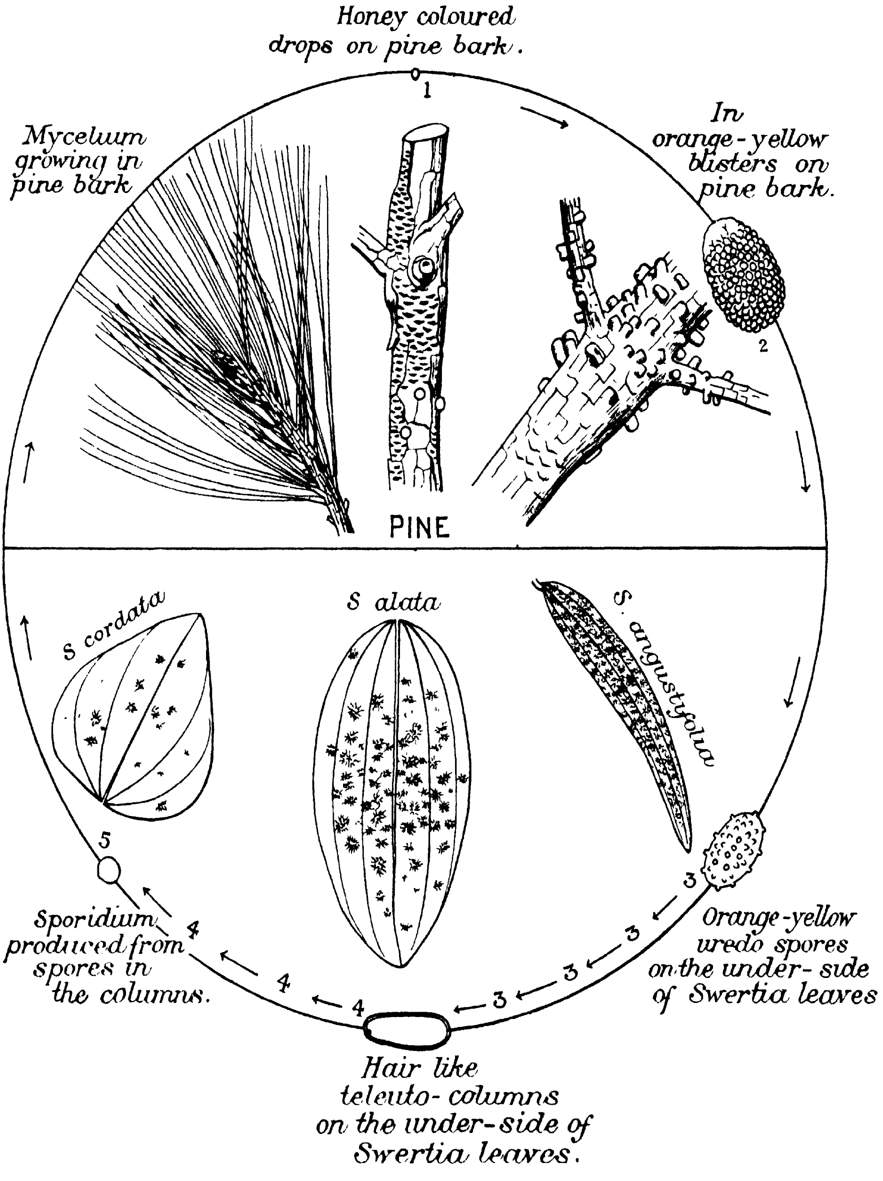


Fig 6 *b*

EXPLANATION OF PLATE XVII.

Diagram representing the life cycle of *Cronartium himalayense.*


Honey coloured drops on pine bark.
1
In orange-yellow blisters on pine bark.
2
Mycelium growing in pine bark
PINE
S cordata
S alata
S. angustifolia
3
Orange-yellow uredo spores on the under-side of Swertia leaves
3
3
3
3
Hair like teleuto-columns on the under-side of Swertia leaves.
4
4
4
Sporidium produced from spores in the columns.
5

INDIAN FOREST RECORDS

Vol. XVIII] 1933 [Part XII.

A STAND TABLE FOR SAL (*SHOREA ROBUSTA*) EVENAGED HIGH FOREST.

1. INTRODUCTION.

A Yield Table for *Sal*, Ind. For. Rec., Vol. X, Part III, was published in 1923. This was based on 115 sample plots of which all were in the United Provinces except 10 in Bengal and 5 in the Central Provinces and no data were given shewing the proportional representation of trees of different diameter classes in a crop of given average diameter. The object of the present publication is to supplement the 1923 yield tables in this respect.

The stand tables are based on 412 measurements taken in 256 sample plots, distributed by provinces as under :—

Province.	Number of plots.	Number of measurements.
Bengal	36	71
Bihar and Orissa	89	115
Central Provinces	42	87
United Provinces	89	139
Total .	256	412

Method of compilation.

The alignment chart method has been adopted for the compilation work as it was found to be most suitable and convenient. This method has been fully described in Appendix II of the Multiple Yield Tables for *Deodar* which should be referred to for details (Ind. For. Rec., Vol. XV, Part VIII, 1933).

The Tables.

The four tables listed below and appearing on the following pages should cover all usual requirements :—

Table 1.—Stand table showing the percentage of the total number of trees up to given diameter limits in crops of various diameters.

Table 2.—Stand table showing the percentage of the total number of trees by 4" diameter classes in crops of various diameters.

Table 3.—Stand table showing the percentage of the total number of trees by 4" diameter classes excluding trees (*a*) below 8" and (*b*) below 12" in diameter.

Table 4.—Numbers of trees per 100 acres of normal forest under rotations of 100 and 120 years, before the annual fellings.

The first two tables are for use in direct connection with the yield tables including all trees down to 1" diameter at breast height.

The third table makes provision for the customary enumeration limits of 8" and 12" d. b. h. and is for use in connection with enumeration data. Tables down to any other desired enumeration limit can readily be derived from Table 1 on similar lines.

The last table gives the number of trees in each of the 4" diameter classes usually adopted for enumeration work which should be present on 100 acres of forest of different qualities with normal stocking and a rotation of 100 or 120 years. This table is derived from the yield tables and Table 1, or actually from the alignment chart from which Table 1 itself was prepared. Similar tables could readily be prepared for any other rotations covered by the yield tables.

TABLE 1.

Shorea robusta (High Forest).

TABLE

Shorea robusta

Stand

Showing the percentage of trees up to given

Diameter limit in inches	Average crop												
	4	5	6	7	8	9	10	11	12	13	14	15	16
	Percent												
1	1	1											
2	12	6	2	1									
3	42	20	10	4	2	1							
4	75	45	25	13	7	3	1	1					
5	93	70	47	29	16	8	4	2	1				
6	99	88	68	48	31	18	10	5	3	1	1		
7		96	85	68	49	33	20	12	6	3	2	1	
8		99	94	83	67	50	34	22	13	8	4	2	1
9		99 5	97 5	92	80	66	50	36	23	15	9	5	3
10			99	96	90	79	65	50	36	25	17	10	7
11				99	95	89	77	64	50	38	26	18	12
12				99 5	98	94	87	76	63	51	39	27	20
13					99	97	93	86	74	64	51	39	29
14					99 5	98 5	96	92	84	74	63	51	41
15						99 5	98	95 5	91	88	73	63	52
16							99	97 5	95	90	82	78	68
17							99 5	99	97	94	89	81	73
18								99 5	98 5	96 5	93	88	81
19									99	98	96	92	88
20									99 5	99	97 5	95 5	92
21										99 5	98 5	97 5	95
22											99	98 5	97
23											99 5	99	98 5
24												99 5	99
25													99·5
26													
27													
28													
29													
30													
31													
32													
33													
34													
35													
36													
37													
38													
39													
40													

NOTE —Figures above 95 per cent. have been

Examples.—(1) In a crop of 14" average diameter, what percentage of the total number of trees

(2) In a crop of 16" average diameter, what percentage of the total number of trees

1.

(High Forest).

Table.

diameter limits in crops of various diameters.

diameter in inches.										Diameter limit in inches.
17	18	19	20	21	22	23	24	25	26	
age.										
										1
										2
										3
										4
										5
										6
										7
1										8
2	1									9
4	2	1	1							10
8	5	3	2	1						11
13	9	5	3	2	1					12
20	14	10	6	4	2	1	1			13
30	22	16	11	7	4	3	2	1		14
42	31	23	17	12	8	5	3	2	1	15
52	42	33	24	18	13	9	5	3	2	16
63	53	43	34	25	19	13	9	6	3	17
72	63	53	44	35	26	19	14	9	6	18
80	71	63	53	44	35	26	19	13	9	19
87	79	71	62	53	44	35	26	19	14	20
91	86	79	71	63	53	44	34	26	19	21
94	91	86	78	70	62	53	44	34	25	22
96·5	94	90	85	78	70	62	52	43	33	23
98	96	94	90	85	78	69	60	51	42	24
99	98	96	93	90	84	77	69	60	50	25
99·5	98·5	97·5	95·5	93	89	83	75	67	58	26
	99	98·5	97	95	92	88	81	73	65	27
	99·5	99	98	96·5	94	91	86	79	71	28
			98·5	97·5	96	93	90	84	77	29
			99	98·5	97·5	95	92	88	82	30
			99·5	99	98	96·5	94	91	86	31
					98·5	97·5	96	93	89	32
					99	98·5	97	95	92	33
					99·5	99	98	96	94	34
							98·5	97	95	35
							99	98	96	36
								98·5	97	37
								99	98	38
									98·5	39
									99	40

read correct to 0·5 per cent.
will be above 16″ diameter? 100—82=18 per cent.
will be between 20″ and 24″ diameter? 99—92=7 per cent.

TABLE 2.

Shorea robusta (*High Forest*).

Stand Table.

Giving the percentage of trees by 4" diameter classes in crops of various diameters.

Diameter class.	Average crop diameter (in inches).																						
	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26
Inches.	Percentage.																						
0—4 . . .	75	45	25	13	7	3	1	1															
4—8 . . .	25	54	69	70	60	47	33	21	13	8	4	2	1	1									
8—12 . . .		1	6	16	31	44	53	54	50	43	35	25	19	12	9	5	3	2	1	1			
12—16 . . .				1	2	6	12	21	32	39	43	46	43	39	33	28	21	16	12	8	5	3	2
16—20 . . .							1	3	4	9	15	22	29	35	37	38	38	35	31	26	21	16	12
20—24 . . .									1	1	3	4	7	11	17	23	28	32	34	34	34	32	28
24—28 . . .												1	1	2	3	5	8	11	16	22	26	28	29
28—32 . . .															1	1	1	3	4	6	10	14	18
32—36 . . .																	1	1	2	2	3	5	7
36—40 . . .																				1	1	2	3
40—44 . . .																							1

Examples.—(1) In a crop of 14" average diameter, what percentage of the total number of trees will be above 16" diameter ?—15+3=18 per cent. Above 20" ? 3 per cent.

(2) In a crop of 16" average diameter, what percentage of the total number of trees will be between 20" and 24" diameter ? 7 per cent.

TABLE 3*a*.

Shorea robusta (*High Forest*).

Stand Table.

Giving the percentage of the total number of trees by 4″ diameter class for partial crop (excluding trees of 8″ and below).

Diameter class.	Partial crop diameter in inches.																	
	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26
Inches.	Percentage.																	
8—12 .	100	93	82	65	49	37	26	18	11	9	5	3	2	1	1			
12—16 .		7	16	31	42	45	46	44	39	33	28	21	16	12	8	5	3	2
16—20 .			2	4	8	16	23	30	36	37	38	38	35	31	26	21	16	12
20—24 .					1	2	5	7	12	17	23	28	32	34	34	34	32	28
24—28 .								1	2	3	5	8	11	16	22	26	28	29
28—32 .										1	1	1	3	4	6	10	14	18
32—36 .												1	1	2	2	3	5	7
36—40 .															1	1	2	3
40—44 .																		1

NOTE.—The figures for partial crop of average diameter 18″ and above are the same as those for the total crop, there being no trees of 8″ and below in the total crop over this diameter.

Examples.—(1) In a partial crop of 14″ average diameter, what percentage of the total number of trees will be above 20″ diameter? 2 per cent.

(2) In a partial crop of 16″ average diameter, what percentage of the total number of trees will be between 20″ and 24″ diameter? 7 per cent.

TABLE 3 (*b*).

Shorea robusta (*High Forest*).

Stand Table.

Giving the percentage of the total number of trees by 4" diameter class for partial crop (excluding trees of 12" and below).

Diameter class.	Partial crop diameter in inches.																
	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26
Inches.	Percentage.																
12—16 . .	100	91	89	83	72	62	53	43	36	29	22	16	12	8	5	3	2
16—20 . .		9	11	15	25	32	37	41	41	41	39	36	31	26	21	16	12
20—24 . .				2	3	6	9	14	19	24	29	33	35	35	34	32	28
24—28 . .							1	2	3	5	8	11	16	22	26	28	29
28—32 . .									1	1	1	3	4	6	10	14	18
32—36 . .											1	1	2	2	3	5	7
36—40 . .														1	1	2	3
40—44 . .																	1

NOTE.—The figures for partial crop of 24" and over are the same as those for the total crop, there being no trees of 12" and under in the total crop over this diameter.

Examples.—(1) In a partial crop of 14" average diameter, what percentage of the total number of trees will be above 20" diameter? 3 per cent.

(2) In a partial crop of 16" average diameter, what percentage of the total number of trees will be between 20" and 24" diameter? 9 per cent.

TABLE 4 (*a*).

Shorea robusta (High Forest).

Numbers of trees per 100 acres of normal forest under a rotation of 100 years, before the annual fellings.

Diameter class.	Number of trees.				
	Quality I.	Quality I-II.	Quality II.	Quality II-III.	Quality III.
Inches.					
8—12 . .	3,870	4,160	4,450	4,620	4,890
12—16 . .	2,520	2,600	2,540	2,360	2,050
16—20 . .	1,420	1,240	1,010	690	440
20—24 . .	600	390	200	100	40
24—28 . .	130	60	30	10	..
28—32 . .	20	10	..	..	..
32—36 . .	10	..	..	..	..

TABLE 4 (*b*).

Shorea robusta (High Forest).

Numbers of trees per 100 acres of normal forest under a rotation of 120 years, before the annual fellings.

Diameter class.	Number of trees.				
	Quality I.	Quality I-II.	Quality II.	Quality II-III.	Quality III.
Inches.					
8—12 . .	3,233	3,483	3,767	3,992	4,333
12—16 . .	2,175	2,333	2,417	2,425	2,300
16—20 . .	1,425	1,383	1,258	1,017	783
20—24 . .	800	642	417	267	125
24—28 . .	283	168	92	42	25
28—32 . .	67	25	17	8	..
32—36 . .	25	8	..	..	..

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INDIAN FOREST RECORDS

Vol. XVIII] 1933 [Part XIII.

ENTOMOLOGICAL INVESTIGATIONS ON THE SPIKE DISEASE OF SANDAL (12).

The Life-History and Morphology of Eurybrachys tomentosa Fabr.

FULGORIDAE (HOMOPT.)

BY

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(Branch of Forest Entomology, Forest Research Institute, Dehra Dun.)

INTRODUCTORY.

Various workers have mentioned this species as a minor pest of agricultural crops, but very little is known about the bionomics and life-history of *E. tomentosa* Fabr., more particularly in its relation with sandal, *Santalum album.* Together with *Sarima nigroclypeata* Mel., this species is found commonly in the sandal forests of South India. During the course of field work in North Salem, Vellore, and Coorg Forest Divisions this species has been found feeding by the writer on both healthy and spiked sandal, in the adult and nymphal stages. It also occurs in the quantitative collections from all localities. The younger stages of this species are liable to be mistaken for older *S. nigroclypeata* nymphs. The late Mr. T. N. Hearsey, Extra Assistant Conservator of Forests, Madras, while engaged on spike work (8, 9), also found this species to be common on sandal and considered it as one of the possible vectors of spike disease. Transmission experiments with this species have been conducted by the writer and Mr. Dover in the Insectary provided by the Indian Institute of Science at Bangalore*. Most of the life-history studies were made in the field laboratory at Denkanikota, North Salem, on sandal alone. Mr. M. Appanna, insectary assistant, made observations on the periods of the different stages in the life-history and his records have also been incorporated.

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* Information on the results of experiments in transmission with this and other species will be published in a future number of this series.

1. SYSTEMATIC POSITION.

Distant (4) recognised only twelve subfamilies of Fulgoridae. Muir (16) has classified the super-family Fulgoroidea into fifteen families and the genus *Eurybrachys* is placed in the family Eurybrachidae.

2. SYNONYMY.

In 1916 Distant (4, p. 22) with regard to a male specimen collected by Dr. T. V. Campbell in copulation with a normal female, stated that " this male specimen differs in having the apical areas of the wing nearly wholly black, with a central transverse white fascia. I take this male specimen to be a varietal form of this very variable species ". Nothing is mentioned about the general colouration of the body or of the tegmen of this male specimen.

All the specimens previously identified as *E. tomentosa* Fabr. in the Forest Research Institute collections are females. The fact that the dimorphic forms of one species have been considered and described as three distinct species, and their relationships remained undiscovered for a period of over seventy-five years is remarkable. During the course of the present investigations three distinct forms have been reared from a batch of eggs laid by one female. Further, the smaller male form with tawny brown tegmina has been seen in copulation with the larger greenish olivaceous female form, both in the field and laboratory.

Hearsey, it appears, was aware of the fact that the male was different in colouration from the female ; and took a pair in copulation from a succulent shoot of *Cassia fistula* at Aiyur on the 19th October 1916. He also caged seven females and three males on the 17th October 1916 on a sandal tree. On the 17th November, all the males and females were found dead ; but a large number of young nymphs were seen by him on that date. On the 9th March 1917, one nymph was found to have transformed to an adult male, and it was of pale brown colour throughout.

In 1906, Distant (4, p. 223) stated that " this is a most variable—both in size and colour—species to identify........... In faded specimens the tegmina are ochraceous, with the fasciae only a little paler and subobsolete. In some these fasciae are testaceous, in others macular and much broken........... There appears to be a variety with the legs concolorous." In a large number of specimens collected by the writer in the field, and also in the identified examples now present in the collection of the Forest Research Institute, the following variations in marking and colouration of the *female* are observed :—

(*a*) Tegmina olive green with flavescent discal fasciae and spots.

(*b*) Tegmina olive green with reddish-orange discal fasciae which may be broken or continuous.

(*c*) Tegmina virescent or stramineous with pale discal fasciae.

(*d*) Tegmina ochraceous with reddish-orange discal fasciae.

(*e*) Tegmina ochraceous with paler discal fasciae.
(*f*) Tegmina of a mixture of green and ochraceous without discal fasciae.
(*g*) Tegmina wholly ochraceous without discal fasciae, and spots.
(*h*) Face, pronotum and mesonotum oilve green.
(*i*) Face olive green, pronotum and mesonotum red.
(*j*) Face ochraceous or brown, pronotum and mesonotum red.
(*k*) Posterior leg not black or fuscous, but red like the anterior or intermediate legs or reddish black.

Specimens of males, bred in the field laboratory, tally with Distant's descriptions of both *Eurybrachys apicalis* Wlk., and *E. dilatata* Wlk. With regard to the later species Distant (4, p. 224) states " it is quite possible that this is only a varietal form of *E. apicalis* Wlk., but at present there is no more reason for that conclusion than there is for its specific distinctness which at least seems more probable ". In a few examples of *E. apicalis* Wlk., and *E. dilatata* Wlk., recently identified by Mr. B. Ovarov through the courtesy of the authorities of the British Museum, it is found that examples with sanguineous legs have been identified as *Eurybrachys apicalis*, and that red colouration at the base of the abdomen is present in all the specimens identified either as *Eurybrachys dilatata* or *E. apicalis* ; while according to Distant's descriptions " legs and base of abdomen sanguineous " is to be seen only in the case of *E. dilatata.* Moreover the rostrum, in all the examples identified as *E. apicalis,* is not " piceous ".

In the male forms reared from the same batch of eggs, sanguineous colouration in the legs, *i.e., E. dilatata* type, is present in some examples while in others the legs are fuscous, *i.e.,* of *E. apicalis* type. The base of the abdomen also varies in coloration ; some are without the red.

Examinations of a large number of specimens from field collections, specimens present in the Forest Research Institute, and also bred examples, show the following variations in marking and colouration in the *male.*

Tegmina pale tawny brown or speckled with fuscous in all cases with—

(*a*) Rostrum fuscous with no red colouration on legs or abdomen.
(*b*) Rostrum fuscous with red colouration at abdomen only.
(*c*) Rostrum fuscous with red colouration only at the third legs.
(*d*) Rostrum fuscous, third leg not black, base of abdomen only sanguineous.
(*e*) Rostrum fuscous, with both legs and base of abdomen sanguineous.
(*f*) Rostrum piceous with red colouration at abdomen only.
(*g*) Rostrum piceous with both legs and base of abdomen sanguineous.

E. apicalis was described by Walker in *List. Hom. II*, p. 368 in 1851, and *E. dilatata* was described by the same author in *List. Hom. II*, p. 398, also in 1851.

From the foregoing, *E. apicalis* is the male, and *E. tomentosa* is the female of one and the same species. *E. dilatata* Wlk. merges into *E. apicalis* Wlk. because of page priority. As the specific name *tomentosa* Fabr. is older and described by Fabricius in *Syst. Entom. II*, p. 324, in 1775, the names *apicalis* Wlk., and *dilata* Wlk., sink as synonyms of *tomentosa* Fabr.

3. DISTRIBUTION.

Bombay; Bangalore, Chikkaballapur, Mysore; Hambantota, Peradeniya, Ceylon; Nilgiri Hills; North Bengal (DISTANT). Aurangabad; Dhulia, Surat, Bombay; Godarwada, Nagpur, C. P.; Penukonda, Pollibetta, Madras (FLETCHER). Aiyur, Coimbatore, Denkanikota, Jawalagiri, Kottur, Nilambur, Noganur, Madras; Fraserpet, Coorg; Poona, Bombay; Raigarh, C. P. (FOREST RESEARCH INSTITUTE).

4. FOOD-PLANTS.

Albizzia lebbek, *Argyreia cuneata*, *Cassia fistula*, *Cipadessa fruticosa*, *Elaeodendron roxburghii*, *Santalum album*, *Scutia indica*, *Terminalia tomentosa*, *Vitex negundo*, *Vitis* sp., *Zizyphus jujuba*, *Z. oenoplia*, *Z. xylopyra* (HEARSEY). *Hibiscus esculentus*, and other Malvaceous plants (LEFROY). *Calotropis gigantea*, Cotton, *Erythrina lithosperma*, *Hibiscus esculentus*, *Zizyphus jujuba*, and various Malvaceous plants, (FLETCHER). *Cajanus indicus*, *Calotropis gigantea*, *Crotolaria paniculata*, *Dichrostachys cinerea*, *Santalum album*, *Zizyphus oenoplia* (N. C. CHATTERJEE).

5. ECONOMIC STATUS.

This fulgorid is less common than *Sarima nigroclypeata* and is found feeding on both healthy and spiked sandal, in the sandal forests of south India. *E. tomentosa* is injurious to sandal both as adult and nymph. The effect of feeding of isolated individuals on sandal is not conspicuous, but when present in large numbers on a sandal branch for a prolonged period, the growth of the shoot is checked, the leaves may wither and be shed, and young shoots and twigs may be killed back as a result of drainage of sap. In the insectary, one year old sandal seedlings were found to shed the leaves and dry up, as a result of the feeding of twelve individuals within ten weeks. *E. tomentosa*, along with other sandal *Homoptera*, is a contributory factor in causing the general condition of stagheadness of sandal seen in the sandal forests of Madras, Coorg and Mysore.

6. Biology.

Habits.—On hatching from the egg, the nymphs remain congregated for some time near the egg clusters, and after twenty four to forty eight hours become active, spread out and run over the sandal plant for purpose of feeding. After moving up and down for a short time the nymph selects a spot, at the axil of leaf or shoot, where it fixes itself temporarily and sucks sap. The young nymph may also be seen on tender shoots or underneath a new leaf. The nymphs of the first, second, and third instars, suck sap from leaves and tender green shoots; while the older nymphs and adults, feed on both green and suberised shoots of healthy and spiked sandal. At places on both green and suberised shoots, where the adults and nymphs, have inserted their probosces and fed, a small dark mark in the shape of a ring is left, which is perceptible with the naked eye. The proboscis penetrates at right angles to the stem, and while feeding the nymphs have the habit of wagging the tail or the anal brushes sideways.

The nymphs of the second, third, and fourth instar are not so restless as the nymph of the first stage. The nymph of the fifth instar is most active. Besides the power of jumping, the nymph in all stages is capable of walking forwards, backwards and sideways. When approached, it at once tries to hide itself, by slipping round to the opposite or shadier side of a shoot or leaf or jumps away. The nymph when about to jump from one shoot to another is seen to raise the anal brushes, and to wave them from side to side. After six to twelve hours of moulting, the adults are able to move about actively. The male is more active than the female. The least touch or disturbance sends the hoppers jumping about. The female, during the period of oviposition, is very sluggish in her movements owing to the weight of the eggs, and can be easily caught. The nymphs are provided with two bundles of long, curved, brownish white anal hairs, which they carry about in an erect position, with the apex of the abdomen lifted. The lower or the basal portion of the anal brushes, is stuck together hard with a waxy secretion, and appears as two projecting brownish rods at first. The apical portion of the anal brush, is loose, hairy and free. The nymphs have the habit of beating the surface of leaves, shoots, branches, and stems on which they happen to be with their anal brushes. They also have the habit of carrying the anal hairs right over the back, and moving them slowly sideways and up and down. The anal hairs are very fragile and are soon broken during capture. During the process of excreting the honeydew the bundles of sensory anal hairs are thrown wide apart, and a clear droplet of viscid fluid is ejected. When the honey dew is thick on the leaves, it imparts a shining appearance, and ants may be seen running up and down the plant and licking the sweet excretion. *E. tomentosa* does not seem to be much attracted to light at night. Only a few odd specimens have been taken at light.

At the time of hatching of eggs both the male and the female are very often seen near the egg clusters.

7. COPULATION.

Copulation takes place in the usual hemipterous fashion during the day on a leaf, on the shoot or on the bole of sandal, the heads of the male and female lying in opposite directions. The period of copulation lasts from three to four hours, and in some cases it was noticed to exceed this time. After copulation the female wanders all over the plant to select a site for egg laying, and the male is always found near the female.

8. OVIPOSITION.

The female *E. tomentosa* six days after copulation, is seen to secrete a white flocculent matter*, from two wax plates situated above the anal aperture. This flocculent efflorescence gradually grows into a large mass on the third day after appearance. On the tenth day after copulation the female begins to lay eggs. When five to eight eggs have been laid, the pair of fulvous, hairy, hatchet shaped external genital organs, which are situated near the anal aperture, begin to work and bring down a sufficient quantity of the white flocculent efflorescence from the wax plates, and spread it over the eggs. As soon as the eggs have been covered with the flocculent material, the female extrudes other eggs, which are caught by the external genital organs, and laid by the side of the previous eggs. When five to eight eggs have been laid again, the process of covering them with the white flocculent material is repeated.

9. SITE OF OVIPOSITION AND NUMBER OF EGGS.

The female oviposits on the surface of leaves, on the bark of shoots and branches, and also in a notch on the bole of sandal. The eggs are laid in elongate oval clusters, each containing 30—42 eggs at a time, and as many as six egg clusters may be laid by one female. In each cluster the eggs touch one another, and the space covered by the egg masses on leaves and bole, varies from 10—15 mm. One bred gravid female was dissected and the number of eggs contained in the ovaries was counted to be 194. The female always covers the egg masses with a thick mat of white flocculent efflorescence. The covered up egg masses are rather conspicuous, and the white flocculent material is probably intended as a protection against the inclemencies of the weather.

10. DURATION OF INCUBATION PERIOD.

The shortest time taken for the eggs to hatch was fifteen days in the month of June, at a mean temperature of 82°F., while the longest time was twenty-one days in the month of August, at a mean temperature of 79°F. The average time of eight records is 18·9 days between mean temperatures of 79°F—87°F, during the months of May, June and August.

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* *See* page 23 for chemical examination of this material.

11. HATCHING.

The nymph emerges by making a slit at the sides of the egg, with the help of the posterior legs, which are provided with toothed trochanters, as is seen in the case of *Sarima nigroclypeata* Mel., and also in *Pyrilla aberrans* Kirby. By rubbing the toothed trochanters against the chorion of the egg from within a slit is first made, and is further widened by the stout spines on the tibia and tarsus of the third legs. The first to come out are the head and rostrum. The emerging nymph moves to and fro by which means the yolk membrane is gradually brought down the thorax, abdomen and legs till the body is entirely free. In one observation the total time taken for the nymph to emerge from the egg, was found to be one hour and thirty-five minutes.

12. DIFFERENT STAGES IN THE LIFE-HISTORY.

The nymph undergoes five moults during an average period of one hundred and one days, and then becomes adult. The nymphs are gregarious only for a short time in their early life, when they are often attended by the parent hoppers. The time spent in the different stages of the life-history is given below.

FIRST NYMPHAL STAGE.

The shortest time taken to moult from the first to the second nymphal stage was 18 days in the month of June, at a mean temperature of 83°F; while the longest time was 24 days also in the month of June, at a mean temperature of 83°F.

Two individuals moulted in 19 days, in the months of May and June at mean temperatures of 84°F and 83°F; and a third moulted in 20 days in September at a mean temperature of 79°F. The average time of twenty-three records is 20·3 days, during the months of May, June and September, at mean temperatures varying between 79°F—84°F.

SECOND NYMPHAL STAGE.

The shortest time taken to moult from the second to the third nymphal stage was 18 days in June-July, at a mean temperature of 77°F; and the longest time was 22 days, at a mean temperature of 79°F, in the month of July. Three individuals moulted in 20 days, during June and October, at mean temperatures of 83°F, 76°F and 77°F; while one moulted in 21 days, in July at a mean temperature of 78°F. The average time of thirty records is 19·9 days during the months of June, July and October, at mean temperatures varying between 76°F—83°F.

THIRD NYMPHAL STAGE.

The shortest time taken to moult from the third to the fourth nymphal stage, was 20 days in July and October, at mean temperatures of 79°F and 78°F; and the longest time was 23 days, in the month of August, at a mean temperature of 79°F. Three individuals moulted in 21 days, during August and October, at mean temperatures of 79° and 78°F. The average time of thirty-six records is 21·1 days during the months of July, August and October, at mean temperatures varying between 78°F—79°F.

FOURTH NYMPHAL STAGE.

The shortest time taken to moult from the fourth to the fifth nymphal stage was 19 days in August, at a mean temperature of 79°F; and the longest time was of 22 days, in the month of November, at a mean temperature of 73°F. Two individuals moulted in 20 days, in July and November, at mean temperatures of 78°F and 74°F; while three individuals moulted in 21 days, during August and November at mean temperatures of 79°F and 74°F. The average time of twenty-seven records is 20·5 days during the months of July, August and November, at mean temperatures varying between 73°F—79°F.

FIFTH NYMPHAL STAGE.

The shorest time taken to moult from the fifth nymphal stage to adult is 19 days in the months of September and December, at mean temperatures of 78°F and 71°F; and the longest time is 20 days in September and December, at mean temperatures of 79°F and 71°F. The average time of twenty records during the months of September and December is 19·6 days, at mean temperatures varying between 71°F—79°F.

13. MOULTING OF NYMPHS.

When about to moult a fine rupture appears from the vertex to the base of metanotum. The emerging nymph or adult slowly crawls out, and the moulted skin is always left attached to the undersurface of leaves or on bark of shoots by the legs. The moulted skin is devoid of anal hairs. The entire process of moulting from one stage to another occupies forty to fifty minutes.

14. LIFE OF ADULT.

In nature the imago of *E. tomentosa* Fabr., should have a maximum life of over two months. In captivity only six records of adult life have been made, between April and December with a range of 56—87 days. The average duration of life is of 69·5 days.

15. FECUNDITY AND SEX RATIO.

The female hopper has been observed to lay 30—42 eggs at a time up to a total of 180 eggs. Counts in the ovaries of a bred gravid female have also been made, and a total of 194 eggs have been found in them. The sex ratio based on reared colonies inside sleeves is 1 : 1.

16. DURATION OF LIFE-CYCLE.

The following table summarises the time variation in the stages of the life-cycle :—

Stage.	Shortest period (days).	Longest period (days).	Average period (days).
Egg	15	21	18·9
First instar	18	24	20·3
Second instar	18	22	19·9
Third instar	20	23	21·1
Fourth instar	19	22	20·5
Fifth instar	19	20	19·6
Total .	109	132	120·3 days

In a total of one hundred and forty-four records of the period of development of the various stages, the difference between the shortest and the longest periods from oviposition to adult is 23 days. The average time is of 120·3 days.

17. EFFECT OF TEMPERATURE ON DEVELOPMENT.

The available records are considered to be sufficient, to form a very accurate idea of the effect of climatic variations on the development of this species throughout the year. Only two broods have been carried through. Most of the transformations of the different stages take place between fifteen to twenty-four days, at mean temperatures varying from 71°F—87°F, during the months of April to December.

One second stage nymph took twenty days to moult to the third stage, at a mean temperature of 76°F, during September-October ; while another took the same time at a mean temperature of 83°F, during the months of May-June. A fifth stage nymph moulted to adult stage during November-December in twenty days at a mean temperature of 71°F ; while another took the same time at a mean temperature of 79°F during August-September.

From above it is inferred that the variations in the time of development are independent of minor variations in climatic conditions. It can further be said that the range of temperature as is experienced at Denkanikota, North Salem, is well within the non-effective limits beyond which an effect would be produced on the rate of development of the insect. *E. tomentosa* is therefore considered to be active throughout the year.

18. NUMBER OF GENERATIONS.

Allowing a fortnight for mating and maturation of the egg, it is evident that a minimum of 109 days, combined with an average life-cycle of 120 days, permit a sequence of three generations in a year. As the adults live for over two months, and the egg laying goes on for a long time, the generations overlap. Under insectary conditions only two broods have been actually carried through. The first brood is during January to April, or earlier, *vide* Hearsey's records on p. 2; the second is during May to August, and the third during September to December.

19. BIOTIC POTENTIAL.

Assuming that the egg laying capacity of this species is 194 eggs per female, the sex ratio is 1 : 1, the number of individuals produced from one egg is one, and the number of generations per year is three, then the annual biotic potential for the species starting with a single pair is $(2\times97\times1)^3=7301384$ individuals.

20. SEASONAL INCIDENCE AND RELATIVE ABUNDANCE FROM QUANTITATIVE AND FIELD COLLECTIONS.

Of the total catch of *E. tomentosa* Fabr., in the quantitative collections, the Aiyur sample plots yielded 53 per cent., the Kottur sample plots 23 per cent., the Jawalagiri sample plots 20 per cent., and the Fraserpet sample plots only 3 per cent., fig 1. In percentage of the total catch in one year, the relative abundance of this species in the different plots is as follows :—

Fraserpet plot No. 1=0, No. 2=0, No. 3=0·6, No. 4=1·9, No. 5=0·6, No. 6=0, No. 7=0 ; Jawalagiri plot No. 8=1·2, No. 9=0, No. 10=5·7, No. 11=1·2, No. 12=4·4, No. 13=1·9, No. 14=5·7 ; Aiyur plot No. 15=15, No. 16=3·1, No. 17=3·8, No. 18=16·4, No. 19=4·4, No. 20=3·1, No. 21=6·9 ; Kottur plot No. 22=4·4, No. 23=1·2, No. 24=1·9, No. 25=5, No. 26=0·6, No. 27=3·8, No. 28=6·3.

The species is abundant in the Aiyur sample plots, pl. 2, fig. 1, more so in the healthy plots 18 and 15. Its abundance in the heavily spiked plot 19 is higher than in the healthy plots 16 and 17. In the spiked plot 20, where the soil was dug up and manured, its abundance is the same as in the healthy plot 16. Both nymphs and adults occur throughout July to February next. In Kottur the species is present in all the sample plots, but is less frequent in the healthy plots 23 and 24, and least frequent in the spiked plot 26. Both nymphs and adults occur throughout March to November, pl. 2, fig. 2. In the Jawalagiri sample plots, it is entirely absent in the spiked plot 9, in which the ground was dug up and the spiked trees were removed every month; but most abundant in the spiked plot 14, where the treatment was more or less the same as in plot 9. This species is probably actually most abundant in plot 10, which was completely burnt by fire in April 1931. The figures represent only seven months' collection in this plot. At Fraserpet, it is most abundant in the spiked plot 4, and absent in the healthy plot 7. It is absent in sample plots 1, 2 and also in healthy plot 6, in which the soil was dug up and manured; but the number of individuals in the Fraserpet sample plots is very small.

The graph for seasonal incidence, pl. 2, fig 3, shows that there is a gradual increase in abundance from March to May with a fall in June and July. The population increases again from July to its highest level in October which is followed by a decrease to February, but the population is less abundant in the months of January to March.

The incidence of nymphs follows much the same trend, indicating the seasonal development of three generations, but at certain periods the nymph population considerably outnumbers that of the adults.

During the period April 1930 to December 1931, a separate collection of over three hundred *E. tomentosa*, was made on sandal from numerous localities by sweep-netting. The monthly totals do not show any marked seasonal variation, and both adults and nymphs occur each month. Both the field and quantitative collections confirm the conclusion that this species is active throughout the year.

21. NIGHT COLLECTIONS.

During the period October to December 1931 collections on sandal were made at night by field assistants in Denkanikota Range for one hour on alternate days and out of a total of 250 specimens of Hemiptera obtained, *E. tomentosa* represented 4 per cent.

22. MORPHOLOGY.

(Description of various stages pl. 1, figs. 1-19.)

EGG (PLATE 1, FIG. 1).

The egg when freshly laid is greenish white in colour. Within twelve hours, the colour of the egg changes to light green. On the sixth day, the colour changes to greenish brown, and on the eighth day, it becomes dark brown. On the twelfth day the egg attains a brownish black colouration.

It is oval, broad at middle, slightly curved inwardly, with a short, pale-brown, dark-tipped, pedicel at the anterior end, and a dark, blunt point, at the posterior end. Chorion perfectly smooth. When examined under the microscope it is seen to be covered with a whitish bloom. Length 1·25 mm ; breadth 0·75 mm.

FIRST STAGE NYMPH.

A freshly hatched nymph is dirty white in colour, within two and a half hours it becomes light brown, and by the end of three hours attains the general brown colour above and pinkish pale brown colour below. In fresh specimens, a whitish line bounded on either side by a pale line, is seen to extend dorso-longitudinally, from the vertex to end of abdomen, but these markings are liable to fade away. On emergence from the egg the nymphs are devoid of anal hairs. After twenty-four to forty-eight hours, two brown projecting rods become visible at the end of which the anal hairs appear to grow. On the sixth day the anal brushes are fairly prominent. On the twelfth day the ratio of the length of the body of the nymph to the length of the anal hairs is about 1:3.

Vertex small, subquadrangular, broader than long, angularly emarginate at base, ampliated posteriorly and at sides, colour dark brown, a little portion at apex whitish with a fine median carination. Face brown, flat, slightly broader than long, angled at sides, angularly ampliated with three transverse pale or white fasciae, a curved fascia below apex, one below middle and a broad fascia at base ; the portion between the upper two fasciae darker, with a double series of globular, translucent, sensory pits at apical and lateral margins, and four sensory pits on the basal fascia, two on either side, Pl. 1, fig. 2. Clypeus brown, stout, convex, smooth. Rostrum dark brown, hairy, reaching upto the third trochanters. Compound eyes red, covered with a white film. Antenna brown, short, cylindrical with a pale stripe on the second joint dorsally. Pronotum, smaller than the following two segments, mottled pale and dark brown, anterior margin ampliated, angularly produced in between the eyes with a fine medio-longitudinal ridge, and a series of 10 globular translucent sensory pits each with a fine seta, placed obliquely in two rows on either side of the median ridge. Mesonotum brown or dark brown, sinuate anteriorly with 4 globular sensory pits, each with a minute seta placed on either side of the median ridge, two placed near middle and two near lateral margins. Metanotum dark brown, tricarinate, angularly produced posteriorly, posterior tip white, with 3 globular sensory pits each with a fine seta placed on either side of the median carinations, two near middle and one near lateral margins. Legs large, hairy, mottled white and pale brown ; tibia of posterior leg with 4 castaneous spines at apex; tarsi two-jointed in all legs, the first tarsal joint of the third leg with 3 spines and 1 spinule at apex. Abdomen with seven discernible segments, broad at base, tapering posteriorly with the membrane in between segments pink and pale areas on the dorsal surface. First abdominal segment transversely smaller than the second which is broadest; sixth abdominal segment is longest, and the apparent seventh abdominal segment telescopes into the sixth. Third, fourth, fifth and sixth abdominal segments each with two globular sensory pits, one on either side near lateral margin on the dorsal surface, and a pair of pale brown patches on the ventral surface. On the apparently seventh abdominal segment, round the inner margin of anal aperture, there are 8 globular sensory pits with two orbicular spots on the outer margin. In pinned and pickled specimens the sensory pits on face, thoracic, and abdominal segments look like small pale or yellow globular tubercles. Two small, circular, white pads are visible, one on each side of the apparent seventh segment, above the anal aperture, from which the whitish brown anal brushes develope. Besides these, are present two elongate membranous wax plates, one on either side of the circular pads. The anal aperture is vertical. Length 1·25—1·75 mm; Length of anal brushes 4 mm; greatest breadth over thorax on the metanotum 0·8 mm—1 mm; breadth between eyes 0·6—0·75 mm; length of antenna 0·6 mm.

SECOND STAGE NYMPH.

In recently moulted specimens, the white and pale brown lines, extending from vertex to end of abdomen, as seen in the first stage nymph are present; thorax whitish pink beneath, abdomen pinkish brown ventrally with two brown patches on the third, fourth, fifth and sixth segments. General colour in mature specimens dark brown above and pinkish brown beneath. The anal hairs are shed with each excuvium and their reappearance in the second stage takes the same time as described in the case of the first stage nymph. On the fourteenth day the ratio of the length of the anal brushes to the length of the body of the nymph was found to be as 1·5:1.

Vertex small, brown, broader than long, emarginate posteriorly, anterior margin pale, a little produced in front of the eyes, laminately dilated at the lateral and posterior margins, with a fine median carination. Face brown, flat, angled at sides, sinuate before clypeus, distinctly broader than long, with three pale white fasciae, one fine curved fascia above middle, another just below middle over the broadest part of face, and the third broad fascia at base, with a series of globular translucent sensory pits, at the apical and lateral margins, and 6 sensory pits on the basal fascia, three on either side; the portion of face between the upper two fasciae darker. Clypeus dark brown, stout, convex, smooth, Rostrum dark brown, hairy, reaching up to the third trochanters. Compound eyes red, with a lateral thin edged triangular tubercle, without facets, situated near the antennae. Antenna brown, second joint stout, robust, cylindrical. Pronotum mottled pale and brown, with a fine medio-dorso-longitudinal carination, anterior margin angularly produced in between the eyes, posterior margin also angularly produced with 16 sensory pits, on either side of the median ridge placed obliquely in double row. Mesonotum brown with a paler area at middle, about twice as broad as pronotum, tricarinate, posterior margin angularly produced, with 10 sensory pits on either side of the median carinations, placed in two groups, one of seven near middle and another of three near lateral margins. Metanotum dark brown or black, faintly tricarinate, anterior margin sinuate, posterior margin angularly produced, with 8 sensory pits on either side of the median carinations, placed in two groups, one of six near middle and another of two near lateral margins. Legs large, hairy, mottled dull white and brown, tibia of posterior leg with 7 stout spines at apex and 5 other spines between the base of tibia and the apical spines. Tarsi two jointed in all legs, the first tarsal joint of the third leg with 3 spines and 4 spinules at apex. Abdomen as in the first instar. First and second abdominal segments without sensory pits ; third, fourth, fifth and sixth segments with a pair of globular translucent pits, each with a minute seta one on either side near posterio-lateral margins. Two circular white pads, are seen on either side of the apparent seventh segment, above the anal aperture from which the whitish brown anal brushes arise. Besides these there are present two membraneous wax plates, enclosed in chitinous triangular rings, one on either side below the circular white pads and lateral to anal aperture. The anal aperture is vertical. Length 2·25 mm—2·75 mm ; length of anal brushes 4·25 mm ; greatest breadth over thorax on the metanotum 1·75 mm—2 mm ; breadth between eyes 1·25 mm—1·5 mm ; length of antenna 1·0 mm.

THIRD STAGE NYMPH (PLATE 1 ; FIG. 3).

General colour dark brown above and pale brown beneath. On the fourteenth day the ratio of the length of the anal brushes to the length of the body of the nymph was found to be as 3:1. The whitish-brown anal brushes do not become conspicuous till the sixth day after moulting.

Vertex brown, mottled, broader than long, laminately dilated at sides and posterior margin, which is circularly emarginate ; with a fine median carination. Face flat, broad, angled at sides, sinuate before clypeus, distinctly broader than long with a fine pale fascia at the broadest portion, upper part of face upto below middle dark brown, lower part pale brown, with a double series of globular translucent sensory pits at the apical and lateral margins, and six sensory pits at the base of face, three on either side, Pl. 1, fig. 4. Clypeus brown to dark brown, stout, convex, smooth. Rostrum dark brown or black, hairy, reaching upto the third pair of trochanters. Compound eyes dark red with a dorsoventral triangular tubercle, which is without facets. Antenna brown to dark brown, second joint stout, cylindrical, with a number of pale spots or foveae. Pronotum as in second stage nymph, with a dark brown patch at the middle of anterior margin ; anterior margin raised and angularly ampliated with a series of 17 sensory pits, placed obliquely in two rows on either side of the median ridge, fifteen in double row and two placed a little apart from the rest. Mesonotum as in the second stage nymph, dark brown, tricarinate with 11 or 12 sensory pits in three groups, a group of seven or eight near middle, three on tegmen region and one near lateral margin of tegmen. Tegmen brown, with the apex pale, shorter than that on metanotum. Metanotum as in the second stage nymph, dark brown, tricarinate, with 10 sensory pits placed in two groups, one of eight near middle and two on tegmen region near lateral margin. Tegmen brown, not conspicuous with the apex pale. Legs large, hairy, mottled pale and brown, tibia of posterior leg with 9 stout, black tipped, spines at apex and 5 or 6 other spines between the base of tibiae and the apical spines ; the same individual is seen to have 6 spines on the right leg and 5 on the left, but the number of spines is never more than six. Tarsi two jointed in the anterior and intermediate legs, and three jointed in the posterior leg ; the first tarsal joint of the third leg with 3 spines and 5 spinules at apex. Abdomen mildly ridged at middle throughout its length, broad at base tapering posteriorly with paler area on the dorsal surface. First abdominal segment without sensory pits, second, third, fourth, fifth, and sixth segments with two globular transclucent sensory pits, each with a minute seta, one on either side near posterio-lateral margins. Anal brushes and wax plates as in the second instar. Length 3·5 mm—3·75 mm ; length of anal brushes 10·5 mm ; greatest breadth over thorax on the metanotum 3 mm—3·25 mm ; breadth between eyes 2 mm ; length of antenna 1·25 mm.

FOURTH STAGE NYMPH.

Similar in general appearance, and colouration to the third stage nymph, with light brown or pale patches on pronotum, middle of mesonotum and on abdominal segments dorsally. On the fourteenth day, the ratio of the length of the anal brushes to the length of the body of the nymph was found to be as 2 : 1.

Vertex brown, mottled, lunate, concavely emarginate posteriorly, broader than long, with a fine median carination, angularly ampliated at sides and posterior margin. Face broad, broader than long, angled at sides with a fine pale fascia at the broadest portion below middle, upper part dark brown, lower part pale brown, with double series of sensory pits at the apical and lateral margins and 6 translucent sensory pits at base of face, three on either side. Clypeus brown to dark brown, speckled, stout, convex, smooth. Rostrum dark brown or black, hairy, reaching upto the third trochanters. Compound eyes reddish brown, sparsely hairy beneath, with a conspicuous triangular tubercle situated dorsolaterally. Antennae placed laterally beneath the eyes, brown or dark brown, second joint robust, cylindrical, hairy, with a number of pale foveae, aristal knob dark brown or black, seta brown. Pronotum mottled pale and brown, anterior margin raised and angularly ampliated with 18 or 19 sensory pits, placed obliquely in two rows on either side of the median carination, sixteen or seventeen in double row near middle and two placed a little apart from the rest. Mesonotum dark brown with a middle pale area, tricarinate, with 10 sensory pits, placed in two groups, one of seven near middle, and the other of three on tegmen region. Metanotum dark brown, tricarinate, with 10 globular sensory pits each with a minute seta placed all in one group near middle. Tegmen conspicuous, smaller than that on mesonotum. Legs large, hairy, mottled pale and brown, tibiae and tarsus as in the third instar. The first tarsal joint of the posterior leg with 3 spines and 6 spinules at apex. Abdomen dark brown pale at middle longitudinally. Abdominal sensory pits, anal brushes and wax plates as in the third instar. Length 5·5 mm ; length of anal brushes 11 mm ; greatest breadth over thorax on the metanotum 4 mm ; breadth between eyes 2·75 mm ; length of antenna 1·5 mm.

FIFTH STAGE NYMPH.

Similar in general colouration and appearance to the fourth stage nymph. On the fourteenth day the ratio of the length of anal brushes to the length of the body of the nymph was found to be as 1·5 : 1.

Vertex mottled, dark brown, lunate, slightly produced in front of eyes, broader than long with a fine median carination, laminately dilated at sides and posterior margin. Face finely obscurely wrinkled with faint speckling, broader than long, angled at sides, upper one-third brown, middle one-third dark brown or black and basal one-third pale brown or pale, with a double series of sensory pits at the apical and lateral margins and 6 translucent sensory pits at base of face, three on either side, Pl. 1 ; fig. 5. Clypeus dark brown, speckled, robust, convex, smooth. Rostrum dark brown or black, hairy, reaching upto the third trochanters. Eyes reddish dark brown, sparsely hairy beneath, with a conspicuous triangular tubercle placed dorsolaterally. Antenna as in the fourth instar, second joint studded with hairs and spines, with a number of olfactory spots. Pronotum as in the fourth stage nymph with 19 or 20 sensory pits placed obliquely in two rows on either side of the median carination ; sixteen or seventeen in double row near middle, and three placed a little apart from the rest. Mesonotum as in the fourth stage nymph, not twice as long as the pronotum with 10 sensory pits placed in two groups, one of seven near middle and the other of three on tegmen region. Tegmen conspicuous, sparsely clothed with minute hairs at the apical area. Metanotum dark brown as in the fourth stage nymph, with 11 sensory pits all placed close together in one group. Tegmen smaller than that on mesonotum. Legs large, hairy, mottled pale and dark brown, tibia and tarsus as in the fourth stage nymph. The first tarsal joint of the posterior leg with 4 spines and 2 spinules at apex. Abdomen dark brown, mildly ridged, pale at middle longitudinally, with the abdominal sensory pits, anal brushes and wax plates as in the fourth stage nymph. Length 6·5 mm ; length of anal brushes 10 mm ; greatest breadth over thorax on the metanotum 4 mm—4·5 mm ; breadth between eyes 2·75 mm ; length of antenna 1·75 mm.

23. ADULT (PLATE 1 ; FIGS. 6, 7).

Female : Head greenish olivaceous or ochraceous ; eyes spinose beneath ; pronotum and mesonotum greenish olivaceous or sanguineous ; metanotum, sternum, and legs purplish red ; posterior tibia and tarsi fuscous, black, or purplish red ; abdomen above greenish white in fresh specimens, fuscous or brownish ochraceous in older specimens. Abdomen beneath pale yellowish green in fresh specimens, fuscous or brownish ochraceous in older specimens, with the transverse fasciae black. Tegmen sparsely clothed with hairs, olivaceous green with small scattered spots and oblique transverse discal fasciae flavescent ; in faded specimens the tegmina are ochraceous, virescent, stramineous or mixed ochraceous and olive-green, with the fasciae only a little paler or subobsolete ; in some these fasciae are testaceous, pale or reddish orange, in others maculate and much broken ; the apical marginal area with a double series of small shining black spots and larger spots near apex of posterior margin ; wings creamy white, with two obliquely transverse black fasciae on apical area. Length from apex of vertex to apex of tegmen 8·75 mm—12·5 mm.

Male : Rostrum fuscous or piceous ; thorax above wholly tawny brown speckled with fuscous ; eyes spinose beneath ; head and pronotum dull stramineous or ochraceous ; mesonotum testaceous or fuscous testaceous ; sternum testaceous or sanguineous ; abdomen above testaceous or ochraceous, beneath black with the lateral margins white in fresh specimens, ochraceous in older specimens and the narrow segmental margins whitish pink in fresh specimens, ochraceous in older specimens ; base of abdomen narrowly sanguineous ; legs less sanguineous and more fuscous in colour ; posterior tibia and tarsus black ; tegmen sparsely clothed with hairs, pale to dark tawny brown, sometimes a little darkly speckled on basal half ; apical area with two prominent black spots, one on anterior, the other on posterior margin, the uppermost sometimes absent and a series of minute black spots on the apical marginal area; wings fuscous or very pale, rarely black, the apical area black or dull fuscous, containing a transverse white fascia. Length from apex of vertex to apex of tegmen 8 mm—10 mm.

24. DEVELOPMENT OF THE ANTENNAE AND THE PRESENCE OF SENSORY HAIRS AND OLFACTORY PITS ON THE SECOND ANTENNAL JOINT.

In all the nymphal stages and also in the adult, the first antennal joint is plain, annular, and much smaller than the second joint, which is robust and cylindrical. In all cases the seta arises from the aristal knob laterally.

In the first instar, the second joint of the antenna is studded with minute brown projections, and also with a few fine hairs. The aristal knob containing the antennal hair is placed at the centre of the apex of the second joint. At the apex of the aristal knob are seen a number of minute tubercles and spines, and on the outer margin of the knob opposite the seta are seen a pair of fine hairs all sensory in function, Pl. 1; fig. 13. In the second instar, the second antennal joint is studded with minute black triangular processes, spines and hairs and it is more spinous and hairy at apex. A few foveae surrounded with thin edged triangular projections are also present. The aristal knob is sparsely studded with minute black triangular processes and opposite the seta are present a few minute spines below which are seen two longish bent hairs probably sensory in function also. In the third instar the second joint is spinulate hairy, with a few stout spines. The number of olfactory pits is greater than those of the second stage nymph, and twenty pits are visible dorsolaterally. Each olfactory pit is surrounded by six thin edged triangular projections, inside which in a circle are present a number of very fine hairs overhanging the pit. Triangular processes occur on the aristal knob sparsely. The pair of long hairs seen in the second stage nymph is absent, but the knob is tubercular opposite the seta. In the fourth instar, the second antennal joint is beset thickly with small hairs, spines and olfactory pits, more so at the apex; and a few stouter spines are also present. The aristal knob is not spinulate and bears four minute spines opposite the seta. In the fifth instar, the second antennal joint, the aristal knob, and the seta are as in the fourth stage nymph, but the four minute spines seen in the latter on the aristal knob are absent. The olfactory pits are situated dorsolaterally, are absent ventrally, and are present in a circle at the apex of the second joint. In the adult stage, besides the short spines and hairs, a few large stout bristles are also present on the second joint of the antenna. There are about thirty olfactory pits, each surrounded at the outer edge by nine thin edged projections, which may be separate from one another or some of them may be contiguous. At the inner edge of the olfactory foveae are seen a number of overhanging fine hairs. The aristal knob and the seta are as in the fifth stage nymph, Pl. 1 ; fig. 14.

The antennae are situated beneath the eyes laterally, are brown or dark brown in colour in all nymphs and adults. In some females the first joint is found to be black and the second joint reddish-brown.

25. DEVELOPMENT OF LEG AND PRESENCE OF TACTILE HAIRS (PLATE 1 ; FIGS. 8, 9, 10).

The trochanter of the posterior leg in all the nymphal stages is toothed or dentate at the inner margin, Pl. 1 ; fig. 11 ; which is not noticeable in the anterior and intermediate legs, nor in any of the legs of the adult.

The intermediate leg is shorter than either the anterior or the posterior leg and the posterior leg is longest in all the nymphal stages and also in the adult. The femur and tibiae of the anterior and the intermediate legs in all the nymphal stages and in the adult is compressed, flat and dilated, that of the intermediate legs less so than the anterior leg. They are studded with hairs and bristles and are devoid of spines.

In the first instar the legs are whitish mottled or banded pale brown ; in the second instar the first leg is whitish mottled brown, second leg pale brown ; in the third instar both the anterior and intermediate legs are whitish mottled brown ; in the fourth instar the first two pairs of legs are mottled brown ; in the fifth instar the first leg is mottled dark brown, second leg mottled brown, and in the adult the first two legs are either sanguineous or as in the fifth stage nymph.

The tibia of the posterior leg in all nymphal stages and in the adult is triangular and studded with hairs and bristles. It is pale brown in the first two nymphal stages, brown in the third stage, dark brown in the fourth stage, mottled dark brown in the fifth stage, and mottled dark brown, black or with red colouration in the adult stage. Except in the first stage nymph, there are at least five spines on the tibia of the posterior leg of all other nymphs and also in the adult, excluding the apical spines. There are four spines at apex of tibia of the third leg in the first instar, seven in the second instar and nine in the third, fourth, fifth instar and in the adult.

Tarsi pale brown, two jointed in all legs, in the first and second stage nymphs. In the third, fourth and fifth stage nymphs the tarsus of the anterior and intermediate leg is two jointed, and that of the posterior leg three jointed, of brown or dark brown colour. In the adult the tarsi of all legs are three jointed, and are dark brown or black in colour. The first joint of the tarsus of the anterior and intermediate leg in all the nymphal stages is much smaller than the second ; both are clothed with hairs, but are devoid of spines. In the adult the first tarsal joint is longer than the second ; and the third tarsal joint is longer than the first and the second put together. The first tarsal joint of the posterior leg in all the nymphal stages and in the adult is longer, stouter, and more conspicuous than the second; is densely clothed with hairs ventrally, which are of a tactile nature; and bears three spines and one spinule at apex in the first instar, three spines and four spinules in the second instar, three spines and five spinules in the third instar, three spines and six spinules in the fourth instar, four spines and two spinules in the fifth instar, and four spines and five spinules in the adult.

The second tarsal joint of the posterior leg in the first and second stage nymph is slender, hairy and bears no spine. The second tarsal joint of the posterior leg in the third, fourth, fifth nymphal stage and in the adult, though stout is very small, smaller than either the first or the third tarsal joint, is clothed with hairs, which are of a tactile nature, fairly densely more so at apex ventrally and bears no spines.

The third tarsal joint of the posterior leg in the case of nymphs of the third, fourth, and fifth stage is slender, subequal in length to the first tarsal joint, hairy, more so in the adult than in the nymphs, and is also devoid of spines.

All tarsi end in a pair of curved, pointed, brown to dark brown claws, which also bear stout bristles. In between the claws are seen a bunch of pale yellow hairs bent at the tips, Pl. 1; fig. 12.

26. DEVELOPMENT OF ANAL PAD, WAX PLATES AND BRUSHES (PLATE 1; FIGS. 14, 15).

As already mentioned, the anal brushes of hairs arise from two white circular pads situated on the apparently seventh abdominal segment. In the first instar, the base of the anal brushes is composed of a circular pattern, consisting of an outer ring of fifteen and an inner ring of five or six small circles. Each small circle is distinct and separate, and is the seat of a single anal hair. Within each circle is seen an internal transparent area, which presumably is the root of the hair. The circles can be differentiated into two kinds; the larger circles, the bases of the thick brown hairs, and the smaller circles, the bases of thin white hairs. Inside the innermost, or first ring, are seen six to nine triangular granules and smaller granular structures are also present in between the circles. Outside each circular pad or the base of the anal brushes is seen another smaller, elongate plate, which is membraneous and is composed of a row of fourteen polyhedral bodies. This is the wax plate, secretions from which bind the anal hairs at base for some distance, and make them appear as brownish rods at first. This binding of the anal hairs at base with wax appears to be necessary, to enable the rods to act as levers in lifting the anal brushes, which are relatively of large size, heavy, and frequently used.

In the second instar exterior to the two rings present in the first stage nymph, are added two more concentric rings. The first or the innermost ring consists of six or seven small circles or hairs, the second of fifteen hairs, the third of twenty-four hairs and the fourth of thirty hairs. Inside the innermost ring small triangular granules are present and smaller granules are also present in between the circles. The position of the wax plates is also altered and instead of being lateral to the circular pads as in the first stage nymph, they are now situated just beneath the circular pads and lateral to the anal aperture. The wax plate is small, bounded by a chitinous triangular ring, and the number of polyhedral bodies contained in it increases to sixteen.

In the third instar exterior to the four rings present in the second stage nymph, is added one more concentric ring of thirty-six circles or hairs. The wax plate is situated as in the second instar, but the number of polyhedral bodies contained in each increases to twenty-six. Inside the innermost ring and also in between the circles small granules are present.

In the fourth instar exterior to the five rings present in the third stage nymph, are added two more concentric rings of circles or anal hairs. The sixth ring is composed of thirty-six circles or hairs and the seventh ring of forty circles. The wax plates are situated as in the third stage nymph, but the number of polyhedral bodies contained in each of them increases to forty-two.

In the fifth instar there are no further additions to the number of rings, but the number of small circles or hairs on the sixth ring increases to forty-five, and that on the seventh ring to fifty-two. In between the sixth and the seventh rings, are present nine extra circles or hairs both above and below and minute granules are also present. The number of polyhedral bodies in each of the wax plates increases to over eighty-five.

In the adult stage, the anal pads and the accessory wax plates with polyhedral bodies seen in the nymphs entirely disappear, and no anal brushes are seen either in the male or in the female. But instead in the female hopper, two cuticular plates, Pl. 1; fig. 18, each with a number of minute pores, situated above the anal aperture, one on either side, are seen from which the white flocculent efflorescence comes out. The female is always seen covered with this material at the dorsal and ventral abdominal segments, and also at apex of abdomen. This flocculent efflorescence is utilised by the female in covering the egg masses. The cuticular plates seen in the female are entirely absent in the male *E. tomentosa*.

The brushes of hairs and pads drop off with the exuvium at every moult, and fresh anal hairs arise in their places as the nymphs continue to feed and grow.

27. ANAL HAIRS (PLATE 1; FIG. 17).

The anal hairs arising from the anal pads of *E. tomentosa* are of two kinds. Firstly, the thick brown hairs, fewer in number, which, except for a short distance at the base, are thickly furnished with fine long spurs, directed forwards throughout the length with a bunch of spurs at the apex; and secondly, the thin white hairs more numerous, not thickly furnished with spurs, and without a bunch of spurs at the apex. Under high power both these types of hairs are found to be transparent within, from which it is inferred that they are hollow or grooved.

28. FUNCTION OF ANAL HAIRS.

It has been observed that the nymphs always flap their tails in the direction from which a disturbance is produced. If a sandal shoot with nymphs is tapped with a pencil, the nymph will very often turn the anal hairs in the direction of tapping, and will begin to flap the anal hairs in quick succession on the shoot. The anal hairs therefore are presumed to be of a sensory nature. The flapping action, combined with the lifting of anal brushes over the back, and wagging it slowly up and down and sideways, may reasonably be supposed to be an attitude of defence taken up by *E. tomentosa* nymphs to scare and drive away any approaching parasitic or predatory insects.

29. DIFFERENCE IN STRUCTURE OF ANAL PADS IN PYRILLA ABERRANS KIRBY, SARIMA NIGROCLYPEATA MEL., AND E. TOMENTOSA FABR.

In the nymphs of *P. aberrans* Kirby, *vide* Misra, 15; pp. 98-99, which belongs to the LOPHODINAE, the bases of anal filaments or threads form a circular pattern of concentric rings of small circles, with an innermost circular transparent patch, which is bordered with six large setae. The small circle in each ring is without minute setae. In the female the anal pad consists of innumerable small circles with a speck in the centre. The anal pads are absent in the adult male. In the case of nymphs of *S. nigroclypeata* Mel., which belongs to the ISSIDAE, the base of the anal bristles consists of circular pattern, but it is not in the form of concentric rings of small circles, as is seen in the case of *P. aberrans* and *E. tomentosa*. Each small circle is bordered with 15-17 minute setae. The anal pads are absent in both adult male and female.

In the case of nymphs of *E. tomentosa*, the base of the anal hairs also consists of a circular pattern of concentric rings of small circles, and the innermost circular transparent patch is without setae, but with triangular granules. Besides the above, wax plates with polyhedral bodies are present. In the adult female, two cuticular plates are present, which consist of a number of minute pores. The anal pads are absent in the male.

30. SENSORY PITS (PLATE 1; FIG. 19).

In pinned and alcoholic specimens, the sensory pits on the face, thoracic and abdominal segments appear as small white, pale, yellow or brown globular tubercles. After treatment with KOH, each abdominal sensory pit, is found to be globular, slightly flattened, with a translucent area at the top, at one side of which is seen a smaller clear area, from which the seta arises. On further examination it is noticed that below the translucent area, is present a series of seven to eight goblet-shaped bodies, inside each of which is seen a fine hair directed downwards. The inner margin of the sensory organ is obscurely divided into four compartments, each containing a number of cells and granules.

31. EYES (PLATE 1 ; FIG. 20).

In the first, second, and third stage nymphs, there are no spines beneath the eyes, but in the fourth, and fifth stage nymphs and in the adult sparsely placed spines are seen beneath the eyes. In the first stage nymph, the thin edged triangular tubercle on the eyes seen in all the other stages, is absent. In the second and third stage nymphs, this tubercle is placed very near the antennae dorso-ventrally. In the fourth and the fifth stage nymph, and in the adult this tubercle is large, conspicuous, pale brown, dark brown, black or red in color ; and occupies a dorso-lateral position. There are no facets on the tubercle, but facets are present all round the tubercle in the adult only.

32. NATURE OF THE WHITE FLOCCULENT EFFLORESCENCE OF THE FEMALE E. TOMENTOSA.

A small quantity of this white material was scraped from the bodies of females, and submitted to Mr. Ghosh and Dr. Puntambaker of the Biochemical branch of this Institute, to whom my thanks are due for its examination. They report as follows : -" This white material was found to be partially soluble in petroleum-ether and so in alcohol, but it was more or less completely soluble in chloroform. On boiling with caustic soda, only a small portion dissolved and the insoluble portion was found to be soluble in chloroform and ether, which did not give the characteristic color reactions of cholestrol or phytosterol. It would therefore appear that the whole of the white flocculent mass is not wax, but some neutral substance the nature of which could not be determined as the material available was too small."

Fletcher (*6, p. 78*) states that in Coorg a considerable proportion, about one in four, of the *E. tomentosa* bugs were infested with a white epipyropid caterpillar which was apparently feeding on the fluffy white waxy excretion of the bug. He also mentions that an epipyropid also occurs on *Eurybrachys* at Coimbatore.

33. MALE GENITALIA.

Pruthi (*17, p. 219 ; pl.xxviii, fig. 235*) gives the following description of the genitalia of *Eurybrachys dilatata* Wlk. (=*E. tomentosa* Fabr.).

"Phallosoma long, but deeply incised, forming distinct lobes, the incisions extending even to the proximal region. Conjunctiva hardly separable from the phallosoma except at the extreme base. Conjunctiva appendages very highly developed, hard, stout and conspicuous bearing small secondary processes. At the base of the conjunctiva appendages, in the position of the vesica, there is another pair of short conical appendages (ap″). Basal plates, their prolongation, and bridge delicate and slender. Parameres flat and broad."

34. Distinction between Nymphal Instars.

The distinguishing characters lie in the number of sensory pits on pro meso and metanotum; in the development of spines on the tibia and apex of the first tarsal joint; and in the number of concentric circles of hairs on the anal pad. A reference to the following table will indicate the different stage nymphs accurately :—

Part of body	Nymph					
	1st Stage	2nd Stage	3rd Stage	4th Stage	5th Stage	Adult
Number of sensory pits on pronotum in groups of .	10+0	16+0	15+2	16 or 17+2	16 or 17+3	0
Number of sensory pits on mesonotum in groups of .	2+2	7+3	7+3+1	7+3	7+3	0
Number of sensory pits on metanotum in groups of .	2+1	6+2	8+2	10+0	11+0	0
Number of tarsal joints to anterior and intermediate legs	2	2	2	2	2	3
Number of tarsal joints to posterior leg . . .	2	2	3	3	3	3
Number of spines at apex of tibia of posterior leg . .	4	7	9	9	9	9
Number of spines and spinules at apex of first tarsal joint .	3+1	3+4	3+5	3+6	4+2	4+5
Number of concentric rings of hairs on anal pad . .	2	4	5	7	7+	0

35. Summary.

Rearing in the insectary has proved that *Eurybrachys apicalis* Wlk. and *E. dilatata* Wlk. are the male and *E. tomentosa* Fabr. is the female of one and the same species. The specific name *tomentosa* Fabr., being older, the names *apicalis* Wlk. and *dilatata* Wlk. sink as synonyms. Next to *Sarima nigroclypeata* Mel., this is a common hopper found on sandal in South India, and feeds on nineteen different plant species besides healthy and spiked sandal. The nymphs of the first, second and third stages suck sap from leaf flush and tender green shoots, while the nymphs of the fourth and fifth stages and also adults suck sap from green shoots and also from shoots with suberised bark. At the place of puncture on shoots, a dark mark in the form of a ring is left. As a result of abnormal drain of sap due to the feeding of a large number of nymphs on a sandal branch, the growth of the shoot is checked, the foliage may wither and be shed, and young shoots and twigs may be killed back. One year old sandal seedlings were found to shed the leaves and dry up, as a result of the feeding of twelve individuals within ten weeks. Along with other sandal *Homoptera*, this species is partly responsible for causing thin crowns and stagheadedness, generally prevalent in sandal forests. The adult life is of over two months and the female has a long oviposition period. Eggs are laid on the leaf, shoot and bole of sandal in clusters. The eggs are covered with a thick mat of white flocculent efflorescence by the female. There are five nymphal stages, and the average time taken to complete development from egg to adult is 120 days. There are three generations in a year and the generations overlap. One hundred and forty four records of the time of development of the different stages in the life history have been made. The life-history studies were mostly conducted at Denkanikota, North Salem, where there is practically no variation in the rate of development in the different seasons. The relative abundance of this species in the different sample plots located in North Salem, Coorg, and Vellore Forest Divisions, where quantitative collections were made during 1930-31 season, has also been given. Like *Sarima nigroclypeata* Mel., this species is also active throughout the year in the sandal forests of Madras, Coorg, and Mysore. All the instars are described, and a table for the identification of nymphs has been prepared. Observations on the development of antennae, legs, anal brushes, sensory pits, eyes, etc., have also been made.

The data recorded in this paper suggest that *E. tomentosa* Fabr. is a species capable of carrying the virus of spike disease of sandal. Experiments with the object of transmitting the disease by means of this insect have been taken up.

N. C. CHATTERJEE.

LITERATURE CONSULTED.

(1) *CHATTERJEE, N. C.* (1931, 1932). *Investigations on the spike disease of sandal.* Indian Institute of Science, Bangalore. *pts. I, II, IV, V, VI,* (V. Subrahmaniyan, Editor.)

(2) *CHATTERJEE, N. C.* (1932). *The Life-history and Morphology of Sarima nigroclypeata Mel.* Ind. For. Rec. Vol. pt. XVIII, pt. XII. pp. .

(3) *COMSTOCK, J. H.* (1918). *The Wings of Insects.* Comstock Publishing House, Ithaca, N. York.

(4) *DISTANT, W. L.* (1906, 1916). *Fauna of British India, Rhynochota ; III, VI.* Taylor and Francis, London.

(5) *FLETCHER, T. B.* (1914). *Some South Indian Insects, p. 492.* Supdt. Govt. Press, Madras.

(6) *FLETCHER, T. B.* (1917). *Proc. Second. Entl. Meeting, Pusa ;* pp. 78, 118, 124, 136.

(7) *FLETCHER, T. B.* (1921). *Annotated List of Indian Crop Pests, Bull. 100, p. 200,* Agric. Res. Inst., Pusa.

(8) *HEARSEY, T. N.* (1916). *Preliminary report on the investigation of spike disease in sandal.* Unpublished, but available from the D. F. O., N. Salem.

(9) *HEARSEY, T. N.* (1919.) *Third report on the investigation of spike disease in sandal.* Unpublished, but available from D. F. O., N. Salem.

(10) *IMMS, A. D.* (1925). *A general text book of Entomology.* Methuen & Co., Ltd., London.

(11) *LEFROY, H. M. AND HOWLETT, F. M.* (1909). *Indian Insect Life ; p. 725.* Thacker Spink & Co., Calcutta.

(12) *MCINDOO, N. E.* (1914). *Olfactory sense of Insects.* Smithsonion. Misc. Coll. Vol. 63, No. 9. Washington.

(13) *MELICHAR, L.* (1903). *Homopterous Fauna of Ceylon.* Felix L. Dames, Berlin.

(14) *METCALF, Z. P.* (1913). *Wing Venation of Fulgoridae.* Ann. Entom. Soc. America, VI, pp. 341-352.

(15) *MISRA, C. S.* (1916). *Indian Sugar Cane Leaf-hopper., Pyrilla aberrans Kirby.* Mem. Dept. Agric. India. Vol. V, No. 2, pp. 73-133.

(16) *MUIR, F.* (1922). *On the classification of Fulgoridae* (Homoptera). *Proc. Hawaii. Entom. Soc. Vol. V ; pp. 205-247.*

(17) *PRUTHI, H. S.* (1925). *The Morphology of Male genitalia in Rhynchota.* Trans. Entom. Soc. London ; pp. 127-256.

(18) *WEBER, H.* (1930). *Biologie der Hemipteren. Biologische, Studienbucher,* No. XI, Julius Springer, Berlin.

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EURYBRACHYS TOMENTOSA Fabr.

EXPLANATION OF PLATE I.

Fig. 1. Egg.

„ 2. Ventral view of head of nymph ; 1st instar s. p.=sensory pit.

„ 3. Ventral view of head of nymph ; 3rd instar s. p.=sensory pit.

„ 4. Nymph 3rd instar showing sensory pits and anal brushes. Diagrammatic.

„ 5. Ventral view of head of nymph ; 5th instar s. p.=sensory pit.

„ 6. Male with expanded wings.

„ 7. Female with expanded wings.

„ 8. Posterior tibia and tarsus of nymph ; 1st instar.

„ 9. Posterior tibia and tarsus of nymph ; 5th instar.

„ 10. (*a*) Anterior, (*b*) intermediate tibia and tarsus of nymph ; 5th instar.

„ 11. Posterior trochanter of nymph, 1st instar highly magnified.

„ 12. Tarsal claws with hairs of nymph ; 5th instar highly magnified.

„ 13. Sensory hairs on antenna of nymph, 1st instar highly magnified.

„ 14. (*a*) Sensory hairs and olfactory pits on antenna of female, (*b*) dorsal view of olfactory pit highly magnified.

„ 15. Base of anal hairs, wax plates and anal aperture of nymph, 1st instar, an ap= anal aperture, an. b= base of anal brush, s. p.=sensory pit, w. p.=wax plate.

„ 16. Base (right) of anal brush and wax plate of nymph, 5th instar, an. b=base of anal brush, w.p.=wax plate.

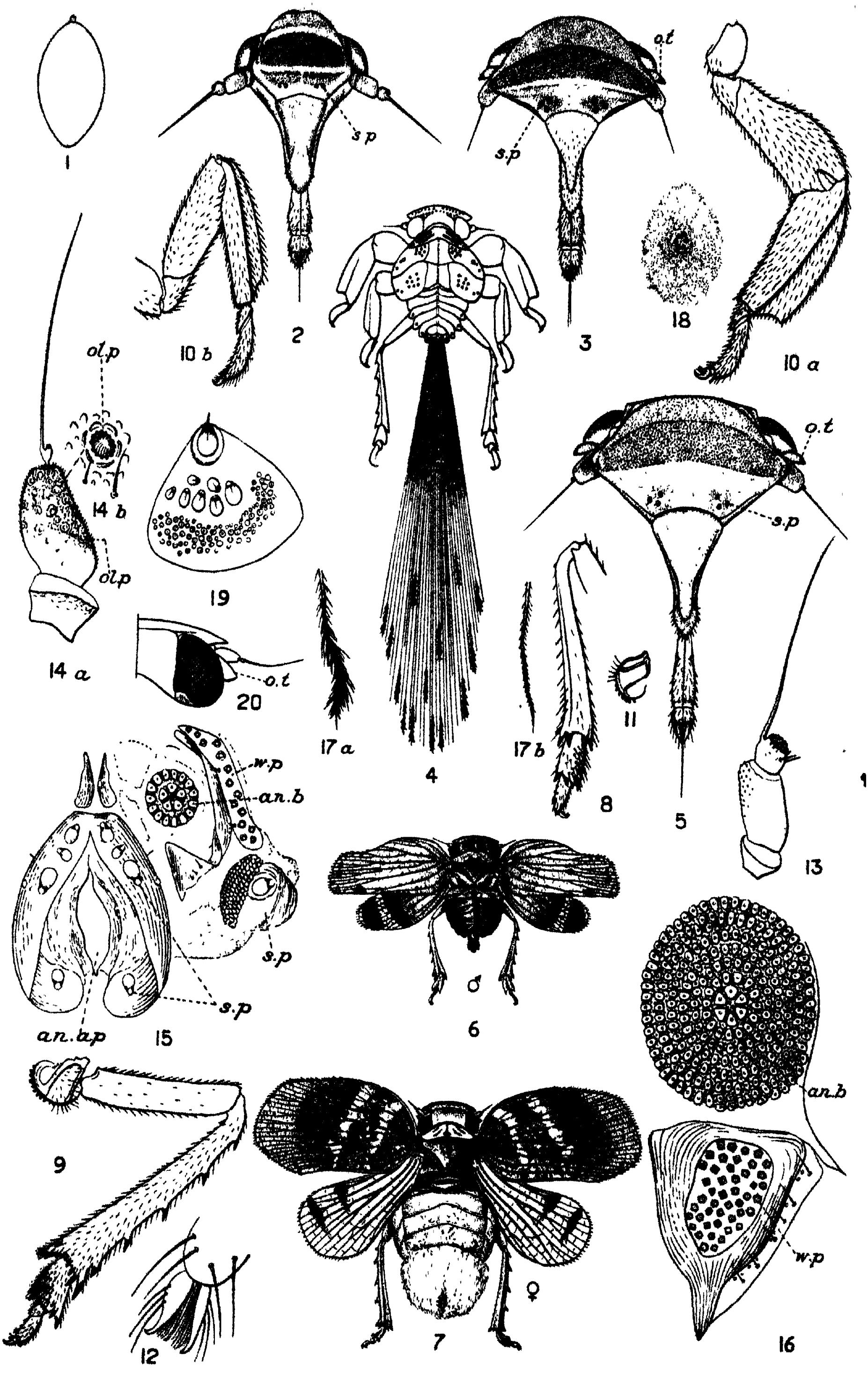
„ 17. Anal hairs (*a*) with bunch of spurs at apex, (*b*)without bunch of spurs at apex.

„ 18. Right cuticular plate with pores of female highly magnified.

„ 19. Abdominal sensory pit of nymph, 3rd stage.

„ 20. Dorsal wiew of right eye of adult showing ocular tubercle, o.t.= Ocular tubercle.

CHATTERJEE—ON THE LIFE-HISTORY AND MORPHOLOGY OF EURYBRACHYS TOMENTOSA, FABR.



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EURYBRACHYS TOMENTOSA Fabr.

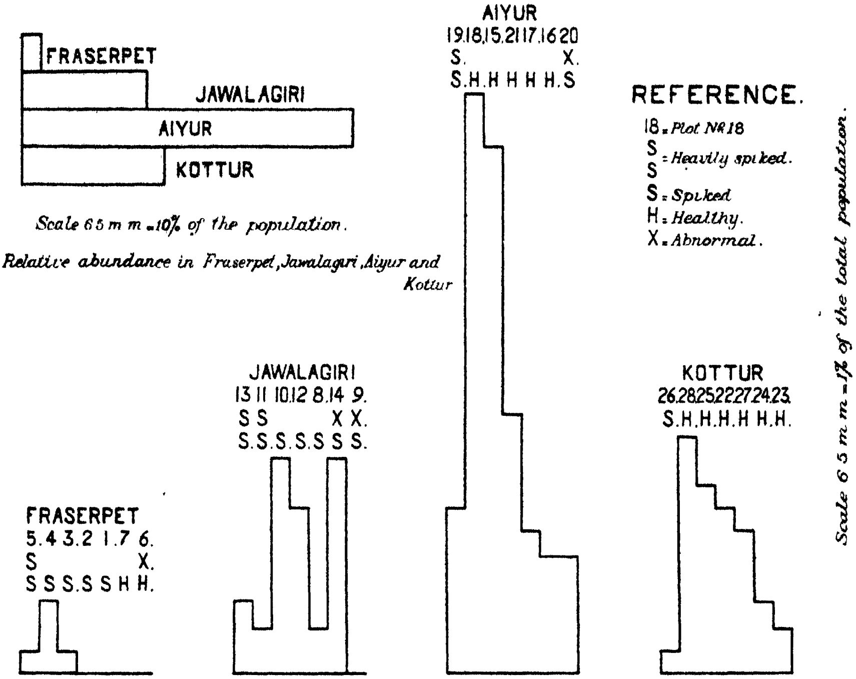
EXPLANATION OF PLATE II.

Fig. 1. Graph showing relative abundance in sample plots 1-28 at Fraserpet, Jawalagiri, Aiyur and Kottur.

„ 2. Graph showing relative abundance in Fraserpet, Jawalagiri, Aiyur and Kottur.

„ 3. Graph showing seasonal incidence based on one year's total. Hatched columns indicate incidence of nymphs.

SEASONAL AND LOCAL INCIDENCE OF EURYBRACHYS TOMENTOSA, FABR.



Scale 6.5 m m = 10% of the population.

Fig.1. Relative abundance in Fraserpet, Jawalagiri, Aiyur and Kottur

Fig 2. Relative abundance in sample plots 1–28.

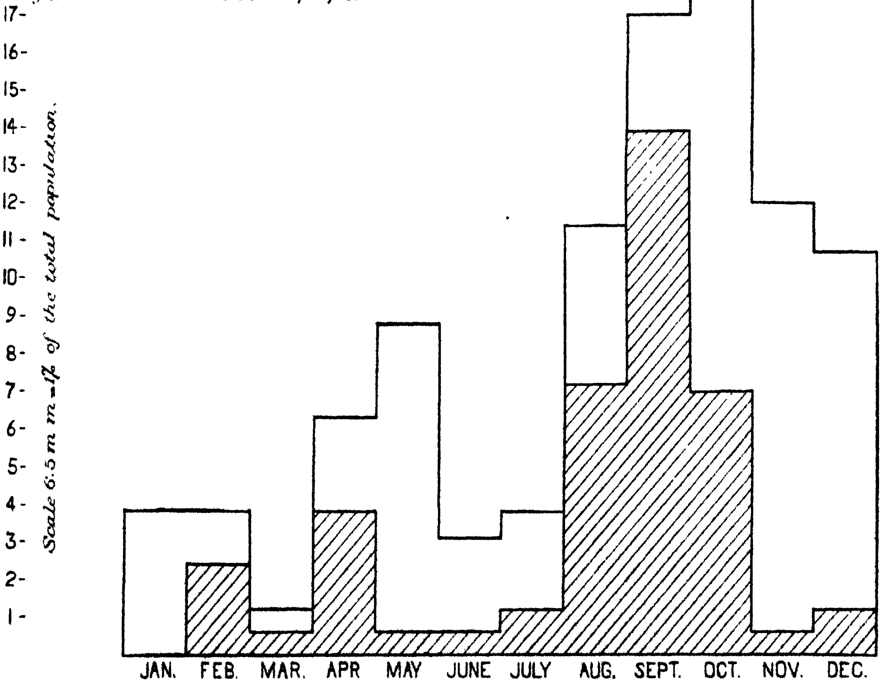


Fig.3. Seasonal incidence based on one years totals Hatched columns indicate incidence of nymphs.

I. A. R. I. 75.

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